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[COMMITTEE PRINT]

REPORT ON THE ACTIVITIES

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

U.S. HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

FIRST SESSION

[No. 32]

----------, 1959

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The chairman of the full committee and the ranking minority member, the Honorable Joseph W. Martin, Jr., are ex officio members of all subcommittees.

LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
Washington, D.C., September 30, 1959.

Hon. OVERTON BROOKS,
Chairman, Committee on Science and Astronautics.

DEAR MR. CHAIRMAN: I am forwarding herewith for committee consideration a report on the committee's activities during the first session of the 86th Congress compiled by Raymond Wilcove, staff consultant, and reviewed by other members of the staff.

This has been the committee's first year and it has been a very busy one. During the course of the past 8 months it has acted upon the first regular annual budget of the Nation's civilian space agency, as well as other legislation; conducted 30 investigations; issued 21 reports; held 146 hearings, heard 447 witnesses, and taken several million words of testimony.

I think it is a record of which the committee can be proud. Various investigations are still underway and much constructive work is being planned for the remainder of the calendar year and for the next session.

CHARLES F. DUCANDER,
Executive Director and Chief Counsel.

LETTER OF TRANSMITTAL.

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ACTIVITIES OF THE HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS

The House Committee on Science and Astronautics, and its companion Senate Committee on Aeronautical and Space Sciences, are the first entirely new parallel committees of both Houses of Congress to be formed since 1892.

The Committee on Science and Astronautics was created by the House of Representatives on July 21, 1958, but its membership was not selected until January 19, 1959. On that date the House selected 24 of the committee's 25 members, with Representative Overton Brooks, of Louisiana, as chairman. The committee roster was completed with the selection of the 25th member on January 29.

Committee Staff

The new committee held its organizational meeting January 20 and voted to seek authority of the House of Representatives to conduct investigations, with the entire committee membership acting as the Investigations Subcommittee.

At the initial meeting and another which followed, February 2, the committee selected the personnel for its professional and investigative staffs. The committee staff, embodying subsequent changes, follows:

PROFESSIONAL STAFF

Charles F. Ducander, Executive Director and Chief Counsel
Dr. Charles S. Sheldon II, Technical Director
Spencer M. Beresford, Special Counsel
Philip B. Yeager, Special Consultant

CLERICAL STAFF

Mrs. Jean Cameron, Assistant Clerk
Mrs. Jane J. Zetty, Secretary
Mrs. Emily Dodson, Secretary
Mrs. Mary A. Robert, Secretary
Miss Mary L. Myron, Secretary

INVESTIGATIONS STAFF

John A. Carstarphen, Jr., Counsel
Raymond Wilcove, Staff Consultant
Richard P. Hines, Staff Consultant
Lt. Col. Francis J. Dillon, Jr., USAF, Staff Consultant
Lt. Col. Paul B. Schuppener, USA, Staff Consultant (March 1–August 22, 1959)
Harney S. Bogan, Jr., Legal Consultant (Jan. 4–July 15, 1959)
Mrs. Eva F. Lopez, Secretary
Mrs. Eunice A. Walker, Secretary
C. Otis Finch, Assistant Clerk

Committee Jurisdiction

The Committee on Science and Astronautics is the successor to the Select Committee on Astronautics and Space Exploration of the 85th Congress which helped enact legislation establishing a civilian space agency, the National Aeronautics and Space Administration.

As a standing committee of the House, the committee exercises legislative jurisdiction over "outer space, including exploration and control thereof, science scholarships, (and) scientific research and development."

It also exercises legislative jurisdiction over "astronautical research and development, including resources, personnel, equipment and facilities," and over the following executive agencies of the Government:

> The Bureau of Standards (including "standardization of weights and measures and the metric system"), the National Aeronautics and Space Administration, the National Aeronautics and Space Council, and the National Science Foundation.

Committee Hearings

The committee's first hearing was held February 2, 1959. The first witnesses at this open session were Dr. T. Keith Glennan, Administrator, and Dr. Hugh L. Dryden, Deputy Administrator, of the National Aeronautics and Space Administration. This was the first of a series of orientation hearings at which representatives of the NASA and the military services briefed the committee on their activities.

The Investigations Subcommittee's initial inquiry was held on February 16. At this open hearing, representatives of the National Science Foundation testified on weather modification and control.

Until the adjournment of the 1st session of the 86th Congress the committee held 120 sessions, of which 90 were open and 30 were closed, at which it considered both legislative and investigative matters. In addition, 26 open and closed sessions were held by the permanent and special subcommittees, for a total of 146 sessions during the 1st session of the 86th Congress; 447 witnesses testified before the committee.

The voluminous testimony taken by the committee filled 12,628 folio (transcript) pages on investigations and another 3,208 folio pages on legislative matters. In addition, 1,231 folio pages of testimony were taken by investigations staff personnel.

Committee Reports and Printed Hearings

During the 1st session of the 86th Congress, the committee submitted the following nonlegislative reports to the House of Representatives:

> Satellites for World Communication (H. Rept. 343) (also listed as Committee No. 3, No. 6)
>
> U.S. Policy on the Control and Use of Outer Space (H. Rept. 353) (also listed as Committee No. 4, No. 5)
>
> The Ground-Cushion Phenomenon (H. Rept. 521) (also listed as Committee No. 10, No. 12)

Status of Missile and Space Programs (H. Rept. 562) (also listed as Committee No. 13)

Nuclear Explosions in Space (H. Rept. 575) (also listed as Committee No. 14)

Research in CBR (Chemical, Biological, and Radiological Warfare) (H. Rept. 815) (also listed as Committee No. 23)

The First Soviet Moon Rocket (H. Rept. 1086) (also listed as Committee No. 33)

Space Propulsion (H. Rept. 1087) (also listed as Committee No. 26)

Dissemination of Scientific Information (H. Rept. 1179) (also listed as Committee No. 27)

Scientific Manpower and Education (H. Rept. 1180) (also listed as Committee No. 28)

Progress of Atlas and Polaris Missiles (H. Rept. 1181) (also listed as Committee No. 30)

Basic Scientific and Astronautic Research in the Department of Defense (H. Rept. 1182) (also listed as Committee No. 31)

Boron High Energy Fuels (H. Rept. ——) (also listed as Committee No. 39)

The committee issued the following legislative reports during the first session, the details of which are discussed later in this report:

Authorizing the National Aeronautics and Space Administration Through the Administrator of General Services to Lease Buildings for the Use of the Administration in the District of Columbia (H.R. 4913) (H. Rept. 189)

Authorizing Appropriations to the National Aeronautics and Space Administration [1959 Supplemental] (H.R. 4990, S. 1096) (H. Rept. 226)

Authorizing Appropriations to the National Aeronautics and Space Administration [1960] (H.R. 7007) (H. Rept. 361)

Amending the National Science Foundation Act (H.R. 8284) (H. Rept. 740)

Amending Public Law 85–880 [Century 21 Exposition] (H.R. 8374) (H. Rept. 744)

National Medal of Science (H.R. 6288) (H. Rept. 824)

In addition to the reports to the House, the committee issued as committee prints the following reports:

Briefing by National Bureau of Standards (Committee No. 29)

Report on the Activities of the Committee on Science and Astronautics (Committee No. 32)

The committee also issued printed hearings on the following legislative and investigative subjects:

Full Committee Consideration of H.R. 4913 with Respect to Authorizing the Leasing of Buildings in the District of Columbia by the National Aeronautics and Space Administration (February 26, 1959) (Committee No. 1)

Full Committee Consideration of H.R. 4990 and S. 1096 with Respect to Authorizing Appropriations to the National Aeronautics and Space Administration [1959 Supplemental] (March 9, 10, 11, 1959) (Committee No. 2)

International Control of Outer Space (March 5, 6, 11, 1959) (Committee No. 7)

The Ground-Cushion Phenomenon (April 13, 14, 15, 1959) (Committee No. 8)

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Satellites for World Communication (March 3, 4, 1959) (Committee No. 9)
Missile Development and Space Sciences (February 2, 3, 4, 5, 9, 10, 17, 18, 24, and March 2, 12, 1959) (Committee No. 11)
Nuclear Explosions in Space (April 10, 1959) (Committee No. 15)
Space Propulsion (March 16, 17, 18, 19, 20, 23, 1959) (Committee No. 16)
1960 NASA Authorization [H.R. 6512, later H.R. 7007] (April 20, 21, 22, 24, 27, 29, and May 4, 1959) (Committee No. 17)
Scientific Manpower and Education (February 25, March 12, 13, May 5, 18, 19, 20, 22, 26, 1959) (Committee No. 18)
Scientific Manpower and Education [Part II—Census of Scientific and Technical Personnel] (June 24, 25, 1959) (Committee No. 19)
Basic Research in Agriculture (February 27, 1959) (Committee No. 20)
Century 21 Exposition [H.R. 7982, H.R. 8203, and H.R. 8374] (July 8, 9, 23, 1959) (Committee No. 21)
Chemical, Biological, and Radiological Warfare Agents (June 16, 22, 1959) (Committee No. 22)
Dissemination of Scientific Information (May 25, 26, 28, June 2, and 17, 1959) (Committee No. 24)
Briefing by National Bureau of Standards (May 7, 8, 21, 1959) (Committee No. 25)
Progress of Atlas and Polaris Missiles (July 28, 29, 1959) (Committee No. 34)
Jupiter Missile Shot—Biomedical Experiments (June 3, 1959) (Committee No. 35)
Weather Modification (February 16, 1959) (Committee No. 36)
Meeting with the Astronauts (Project Mercury—Man-in-Space Program) (May 28, 1959) (Committee No. 37)
National Defense Plan Briefing (June 23, 1959) (Committee No. 38)

LEGISLATION

Six bills reported by the committee during the first session have been passed by the Congress and signed by the President to become public laws. In addition, 13 other bills referred to the committee were tabled because they were superseded by the bills which were reported out and enacted, or (in one case) the committee voted to accomplish the same end by a committee resolution. There remain 20 other bills pending on the calendar, together with 1 House resolution, 1 House joint resolution, and 3 House concurrent resolutions.

The legislative history of the six bills now enacted is as follows:

H.R. 4913 (a bill to amend the National Aeronautics and Space Act of 1958 to authorize the National Aeronautics and Space Administration to lease buildings in the District of Columbia for its use)

This was the first bill to be considered by the committee and the first to be reported by the committee. This bill was introduced by Mr. Brooks of Louisiana, February 24, 1959. The committee held hearings February 26 and tentatively agreed to report the bill with an amendment. The bill was considered again March 6, and the amendment was put into final form, following which the committee gave its final vote to report the bill.

The bill was reported to the House March 9, accompanied by House Report 189. It was passed by the House March 16. The Senate Committee on Aeronautical and Space Sciences reported the bill April 20, accompanied by Senate Report 213. It passed the Senate April 29. It was signed by the President May 13 as Public Law 86–20.

S. 1096 (a bill to authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes)

This bill was introduced by Senator Johnson of Texas and Senator Bridges February 17, 1959, and referred to the Committee on Aeronautical and Space Sciences. It was reported March 5, accompanied by Senate Report 82, and passed the Senate March 10. The act was referred March 11 to this committee.

Prior to Senate action, H.R. 2971 had been introduced by Mr. Brooks of Louisiana January 21, 1959. It provided in a single bill authorization of supplemental funds for NASA for the balance of the 1959 fiscal year and also for the 1960 fiscal year. When a decision was made to handle separately the authorizations for 1959 and 1960, Mr. Brooks introduced February 25 another bill, H.R. 4990, which was identical with S. 1096, covering fiscal 1959 only. Hearings were held on H.R. 4990 March 9, 10, and 11.

On March 11, the committee agreed to report H.R. 4990 with an amendment, and this in effect tabled H.R. 2971. Then the committee substituted S. 1096 for the House bill, incorporating the House amendment. The amended Senate bill was reported to the House March 18, accompanied by House Report 226, and passed April 14. [It was called up under House Resolution 240, accompanied by House Report 270 filed April 13 by the Rules Committee.] The Senate agreed to the House amendment April 15. The President signed the act on April 22 as Public Law 86–12.

The purpose of the act was to provide $48,354,000 in supplemental funds for fiscal 1959, including $3,354,000 for salaries and expenses, $20,750,000 for research and development, and $24,250,000 for construction and equipment. The construction and equipment item included $9 million for the Jet Propulsion Laboratory in Pasadena, $12,050,000 for tracking facilities, and $3,200,000 for propulsion facilities.

H.R. 6288 (a bill to establish a National Order of Science to provide for recognition for individuals who make outstanding contributions in science and engineering)

This bill was introduced April 13, 1959, by Mr. Anfuso. Hearings were held July 30, August 5 and 6. Various amendments to the bill were approved tentatively August 5. On August 6, this action was formalized by a final vote.

The bill was reported with amendments to the House on August 10, accompanied by House Report 824. It was further amended on the floor and passed by the House August 19. The Senate passed it August 20. The President signed the act August 25 as Public Law 86–209.

The committee amended the title to read, "A bill to establish a National Medal of Science to provide recognition for individuals who make outstanding contributions in the physical, biological, mathematical, and engineering sciences." It provided that not more than

20 individuals were to be selected in any one year by the President on the basis of recommendations by the National Academy of Sciences. The further amendment on the floor of the House removed an earlier provision for cash awards to winners of the medal.

H.R. 7007 (a bill to authorize appropriations to the National Aeronautics and Space Administration for salaries and expenses, research and development, construction and equipment, and for other purposes)

This was the major legislation acted upon by the committee during the 1st session of the 86th Congress. The first big money bill of the new committee authorized funds for NASA for the 1960 fiscal year beginning July 1, 1959.

This bill was introduced on May 7, 1959, by Mr. Brooks of Louisiana.

As previously noted, H.R. 2971, introduced by Mr. Brooks January 21, was to have provided for both the 1959 fiscal year supplemental and for the 1960 fiscal year regular authorization for NASA. In effect, H.R. 2971 was tabled when the committee reported out S. 1096 covering the 1959 supplemental authorization.

Mr. Brooks accordingly introduced H.R. 6299 April 13, covering the 1960 authorization for NASA.

On April 20, Mr. Brooks introduced H.R. 6512, also covering the fiscal 1960 authorization for NASA, but differing from the earlier bill in that only the construction and equipment total and breakdowns were made specific in amount. The committee held hearings or meetings April 20, 21, 22, 23, 29, May 4, 6, and 19 on matters related to the fiscal 1960 authorization. In addition, four subcommittees held hearings on the same subject, including meetings April 24, 27, and 28.

The full committee received subcommittee recommendations April 29. Committee amendments were adopted May 6 and it was decided to draft a clean bill, H.R. 7007, which in effect tabled both H.R. 6299 and H.R. 6512.

H.R. 7007 was introduced by Mr. Brooks May 7. The bill was reported to the House May 14, accompanied by House Report 361, and passed May 20. The Senate Committee on Aeronautical and Space Sciences reported the act with amendments June 2, accompanied by Senate Report 332. It passed the Senate with amendments June 4. The Senate requested a conference June 4, but the House agreed to the Senate amendments June 8. The President signed the act June 15 as Public Law 86–45.

The act authorized funds for aircraft, missile, and spacecraft research; scientific investigations in space; satellite applications investigations; space operations technology; space propulsion technology, including the development of a 1-million-pound-thrust single-chamber engine; space systems technology; tracking and data acquisition; and the development of the Scout, Delta, Vega, and Centaur space vehicles.

The legislation also authorized funds to pay for the employment of an additional 1,027 employees during the 1960 fiscal year, bringing the total number of NASA personnel to 9,988.

When the bill was reported to the House, it authorized $480,550,000 for fiscal year 1960, including $94,430,000 for salaries and expenses, $333,070,000 for research and development, and $53,050,000 for construction and equipment. Construction and equipment proj-

ects authorized included $4,580,000 at Langley Research Center, Hampton, Va.; $6,555,000 at Ames Research Center, Moffett Field, Calif; $6,860,000 at Lewis Research Center, Cleveland, Ohio; $2,805,000 at High Speed Flight Station, Edwards Air Force Base, Calif.; $14,000,000 at the Goddard Space Flight Center, Beltsville, Md.; $3,000,000 at Pacific Missile Range, Point Arguello, Calif.; and $15,250,000 for the global tracking and communications facilities and for Project Rover.

This committee, with subsequent House approval, struck out an NASA request for $4,750,000 for an exotic fuel experiment station on the grounds that a site had not yet been picked. The committee was prepared to consider a supplemental authorization for this purpose as soon as a site had been selected. The Senate, however, approved the request, increasing the authorization to $485,300,000, and the House agreed.

H.R. 8284 (a bill to amend the National Science Foundation Act of 1950, as amended, and for other purposes)

This bill was introduced by Mr. Brooks of Louisiana July 20. Its purpose was to increase the efficiency of operation of the National Science Foundation and to clarify its authority.

The National Science Foundation was established in 1950. As late as fiscal year 1955, funds appropriated for the Foundation amounted to approximately $12 million. By the 1959 fiscal year, the Foundation's appropriation had risen to $139 million and for the 1960 fiscal year the Congress appropriated $154,773,000.

Hearings were held on H.R. 8284 July 22 and 24. The committee adopted amendments to the bill July 22 and 24. On July 28, the committee agreed to report the bill as amended. The bill was reported to the House July 30, accompanied by House Report 740. It was further amended on the House floor and passed August 17.

Meanwhile, Mr. Hill introduced July 30 in the Senate, S. 2468 which corresponded to the original version of H.R. 8284. This bill was referred to the Committee on Labor and Public Welfare. S. 2468 was reported to the Senate, accompanied by Senate Report 732, August 19, with amendments. On August 24, the Senate substituted the House-passed bill, H.R. 8284, for S. 2468. The President signed the act September 8 as Public Law 86–232.

H.R. 8374 (a bill to amend Public Law 85–880, and for other purposes)

The purpose of the bill was to amend Public Law 85–880 by adding to the name of the forthcoming World Sciences—Pan Pacific Exposition at Seattle, Wash., the phrase "now known as Century 21 Exposition." It also extended the time period covered by the act to include 1962. Among other adjustments, it provided an authorization not to exceed $12,500,000 for the cost of Federal participation in the exposition. The original act had authorized such appropriation as might be necessary to carry out the provisions of the law.

The exposition, the first international exposition to be held in the United States since 1939, is scheduled to open May 10, 1961, and close in October 1962.

The exposition will commemorate the centennial of the physical fixing of the boundary line between the United States and Canada, depict the role of science in modern civilization, and exhibit the varied cultures of the nations bordering on the Pacific Ocean.

A section of the exposition would be known as the World of Science. There the Federal Government, with the cooperation of the National Science Foundation, would create Federal exhibits in order to make initial presentations in each field of science. These areas are planned to arouse an interest and understanding among both youths and adults in the four basic sciences: life sciences, energy, man, and space.

H.R. 8374 was introduced by Mr. Brooks of Louisiana, July 23, 1959. Earlier, on May 28, identical bills had been introduced for this same purpose but referred to the Committee on Foreign Affairs. These were H.R. 7431 (Mr. Horan), H.R. 7434 (Mr. Mack), H.R. 7435 (Mr. Magnuson), H.R. 7436 (Mrs. May), H.R. 7438 (Mr. Pelly), H.R. 7440 (Mr. Tollefson), and H.R. 7443 (Mr. Westland).

The Committee on Foreign Affairs discharged its seven bills June 24 and they were re-referred to this committee.

Mr. Brooks on June 26 introduced an identical bill, H.R. 7982, on which this committee held hearings July 8 and 9. The committee adopted amendments July 9 and at the same time called up and tabled H.R. 7431, H.R. 7434, H.R. 7435, H.R. 7436, H.R. 7438, H.R. 7440, and H.R. 7443. The committee voted to introduce a clean bill incorporating these amendments and July 14 Mr. Brooks introduced H.R. 8203. On July 23, the committee adopted additional amendments and voted again to introduce another clean bill. Accordingly Mr. Brooks introduced H.R. 8374 on July 23. The committee tentatively approved H.R. 8374 July 24, and July 28 voted to report it out. The bill was reported to the House August 3, accompanied by House Report 744, agreed to by the majority of the committee, and accompanied by minority views of two members and individual views of a third member. H.R. 8374 passed the House August 18. [It was called up under House Resolution 345 accompanied by House Report 896 filed August 13 by the Rules Committee.]

S. 2065, for the same purpose, had been introduced May 28 by Mr. Magnuson for himself and Mr. Jackson, and was referred to the Committee on Foreign Relations. The Committee on Foreign Relations reported the bill to the Senate with amendments August 12, accompanied by Senate Report 686.

The Senate substituted H.R. 8374 for S. 2065 and passed it with amendments August 21. The House asked for a conference August 27. The conference report was approved by the Senate August 29, filed in the House September 1 (H. Rept. 1104), and was approved by the House September 2. The President signed the act September 9 as Public Law 86–250.

Investigations

The committee's action on January 20, requesting authority to conduct investigations, was followed 6 days later by House approval of House Resolution 133.

The text of the resolution follows:

> *Resolved*, That, effective from January 3, 1959, the Committee on Science and Astronautics, acting as a whole or by subcommittee, is authorized to conduct full and complete studies and investigations and make inquiries with respect to any matter or matters in or related to the fields of astronautical research and development (including resources, personnel, equipment, and facilities), outer space (including exploration and control thereof, and air and space law), and

other scientific research and development (including international scientific cooperation) coming within the jurisdiction of such committee.

Provided, That the committee shall not undertake any investigation of any subject which is being investigated by any other committee of the House.

For the purpose of carrying out this resolution the committee or subcommittee is authorized to sit and act during the present Congress at such times and places within the United States, whether the House has recessed, or has adjourned, to hold such hearings, and to require, by subpena or otherwise, the attendance and testimony of such witnesses and the production of such books, records, correspondence, memoranda, papers, and documents as it deems necessary. Subpenas may be issued under the signature of the chairman of the committee or any member of the committee designated by him, and may be served by any person designated by such chairman or member. The chairman of the committee or any member designated by him may administer oaths or affirmations to witnesses.

The committee shall report to the House as soon as practicable during the present Congress the results of its studies, investigations, and inquiries, together with such recommendations as it deems advisable. Any such report which is made when the House is not in session shall be filed with the Clerk of the House.

On January 29, the House approved House Resolution 139 allocating $300,000 for the expenses of the "studies, investigations and inquiries" authorized by the previous resolution.

The text of House Resolution 139 follows:

Resolved, That effective January 3, 1959, the expenses of the studies, investigations, and inquiries authorized by H. Res. 133 incurred by the Committee on Science and Astronautics, acting as a whole or as a duly authorized subcommittee, not to exceed $300,000, including expenditures for employment, travel, and subsistence of attorneys, experts, and consultants (including personnel of the Library of Congress performing services on reimbursable detail) and clerical, stenographic, and other assistants, shall be paid out of the contingent fund of the House on vouchers authorized by such committee or duly authorized subcommittee, signed by the chairman of such committee, and approved by the Committee on House Administration.

During the course of the first session the committee engaged in many investigations.

Subjects under study, on most of which hearings were held, included:

Air Force missile and space program.
Navy missile and space program.
Army missile and space program.
Weather modification and control.
Department of Defense research and engineering program.

Special projects program of the Advanced Research Projects Agency.
Soviet missile and space program.
Status of scientific education in the United States.
Basic research in agriculture.
Defense Department policy on Nike-Zeus antimissile missile.
International telecommunications and space communication satellites.
Space propulsion.
Visual satellite tracking.
Space law and the international control of space.
Interrelationship of U.S. Government space programs.
Nuclear explosions in space (Argus project).
Ground-effect phenomenon.
Saline water research.
Dissemination of Scientific Information.
Soviet moon shot (Mechta).
Scientific manpower program in the United States.
The training of Project Mercury astronauts.
Research in chemical, biological, and radiological warfare.
Jupiter shot—biomedical experiments.
National defense plan.
Progress of Atlas and Polaris missiles.
Contracts and contract procedures of executive agencies.
Patents and scientific inventions.
Government high-energy aircraft fuel program.
Oceanographic research.

Major Subjects Under Investigation

RESEARCH IN CBR (CHEMICAL, BIOLOGICAL, AND RADIOLOGICAL WARFARE)

The possibility of chemical, biological, and radiological warfare has for some time disturbed the Nation's defense planners. In an effort to focus attention upon this relatively little known aspect of war, the committee held a series of hearings on research in CBR warfare.

The committee held open and executive hearings on the subject June 16 and 22. Ten Army witnesses were heard, as follows:

Baker, Col. Samuel E., Chemical Corps, Deputy Assistant Chief Chemical Officer, Planning and Doctrine, Office of the Chief Chemical Officer, U.S. Army.
Creasy, Maj. Gen. William M., U.S. Army (retired), former Chief Chemical Officer, and now director of engineering development, the Lummus Co.
Gibbons, Col. Gilbert P., Chemical Corps, Chief, Logistics Planning Division, Office of the Chief Chemical Officer, U.S. Army.
Gordon, Dr. Nathan, Director of Technical Operations, Chemical Corps Intelligence Agency, U.S. Army.
Lindsey, Lt. Col. Douglas, Medical Corps, Director of Medical Research, Chemical Warfare Laboratories, Army Chemical Center.
McNamara, Dr. Bernard P., Chief, Toxicological Division, Medical Research, Chemical Warfare Laboratories, Army Chemical Center.

Schwab, Dr. John L., Deputy Commander for Scientific Activities, U.S. Army Chemical Corps Research and Development Command.

Sim, Dr. M. Van, Chief, Clinical Research Division, Chemical Warfare Laboratories, Army Chemical Center.

Stubbs, Maj. Gen. Marshall, Chief Chemical Officer, U.S. Army.

Willman, Lt. Col. William G., Chemical Corps, Assistant to Deputy Chief Chemical Officer for Scientific Activities, Office of the Chief Chemical Officer, U.S. Army.

In addition to the witnesses, the committee received a demonstration of two physically incapacitating psychochemicals and viewed films showing the effect certain psychochemicals have upon the human mentality.

Among the facts gleaned at the hearings were these:

1. The CBR field offers, potentially, a more dangerous likelihood of international anarchy than the threat of nuclear warfare.

2. The Soviet Union and other Communist countries are actively engaged in widespread research in CBR agents and in the large-scale manufacture of materials and delivery devices.

3. Despite this, CBR research in the United States is limited to about $35 million to $40 million a year, about one one-thousandth of the American defense budget.

4. The conclusion is inescapable that the Soviet Union and other Communist countries plan to use CBR if they find it to their advantage. Soviet General Drugov has stated: "Many of our scientists * * * regard research on the actions of poisons and on the development of antidotes to be their patriotic duty." Still another Soviet military leader, Admiral Gorshikov, declared that future war will be characterized by "various means of mass destruction, such as atomic, thermonuclear, chemical, and bacteriological weapons."

5. Soviet chemical weapons, and their protective equipment, are modern and effective. The Russians are capable of participating in large-scale gas warfare. Soviet medical and technical reports show that they are equally well versed in biological warfare.

6. CBR weapons, unlike nuclear, are relatively cheap to produce, and this poses the possibility that a very powerful nation with great industrial resources and standing military forces could be defeated by a smaller nation by quiet and sustained effort in the CBR field.

7. New agents which have been developed since World War II, such as certain of the nerve gases, cannot be detected by the human senses and can cause death in less than a minute of exposure. Still others can incapacitate the individual, mentally and physically, without causing lasting damage to the human body.

As a result of its hearings and further study on the problems of research in CBR, the committee offered the following recommendations:

(1) There must be a strong and continuous intelligence effort conducted by the United States as a protective measure to keep abreast of foreign developments in the fields of CBR if this country is to have time to develop adequate passive defense and other countermeasures.

(2) Surveillance of foreign activities might also give this Nation its only inkling of imminent use of CBR against the United States, and therefore is important for this reason, too.

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(3) There is an urgent need for greater public understanding of the dangers and uses of CBR if proper support is to be given to our defenses and countermeasures.

(4) In any consideration of international disarmament, a special effort must be made not to overlook the great potential of CBR and the ease of evading detection of CBR activities.

(5) There is an urgent need for a higher level of support on a continuing, longrun basis in order to develop better detection and protection measures against possible employment of CBR against this country.

(6) Civil defense plans of this country should include a more positive effort at providing shelters which are proof against CBR attack, at providing more masks and protective clothing, and in public instruction in defensive measures.

(7) More positive and imaginative attention should be given to the problems of detecting and guarding against use of CBR by saboteurs aimed at disrupting key activities in time of emergency.

(8) The committee views CBR as a weapon which is not competitive with nuclear weapons, but complementary to them, designed to do a different job.

(9) The committee cannot bring itself to describe any weapon of war as "humane," and makes no moral judgment on the possible use of CBR in warfare. It does recognize that ignoring CBR will not remove the problem of its existence or its possible employment against the United States.

(10) It is granted that some forms of CBR offer the prospect and the hope of winning battles without taking human life or destroying homes and factories. If force must be used, this is better than many of the alternatives. But it must also be recognized that even if the United States is attacked with the new "gentle" weapons, the consequences of any defeat for our Nation would be just as dangerous to our national goals and life.

(11) It is also recognized that in the present world situation with other countries pursuing vigorous programs of CBR development, the best immediate guarantee the United States can possess to insure that CBR is not used anywhere against the free world is to have a strong capability in this field, too. This will only come with a stronger program of research.

(12) At the present time, CBR research is supported at a level equivalent to only one one-thousandth of our total defense budget. In light of its potentialities, this committee recommends that serious consideration be given to the request of Defense officials that this support be at least trebled. Only an increase of such size is likely to speed research to a level of attainment compatible with the efforts of the Communist nations.

(13) If CBR is to be considered a deterrent force in the U.S. arsenal of weapons, the program of research advocated here will have to be accompanied by an adequate program of manufacture and deployment of CBR munitions.

(14) CBR warfare is not particularly expensive as compared with many other modern forms of warfare, particularly when considered as an incremental cost added to already necessary delivery techniques employed for nuclear weapons. This is a

further reason why this investment must be given careful consideration.

(15) The research being done in CBR has already yielded a variety of peacetime benefits, including antidotes for poisons, new serums to prevent disease, greater understanding of how diseases are spread, new insecticides, and fundamental knowledge of life processes. There is no real separation possible between potential military application of chemical and biological knowledge and peaceful applications. These peaceful applications are required in any case, and deserve added support for the national welfare.

(16) The United States is in a research and development race, particularly with the Soviet Union, whether it be for peaceful or military purposes. The study by this committee of CBR reinforces our general view of the urgency of the overall race and the necessity of full public understanding and support of science and technology everywhere in our Nation.

The testimony on CBR research has been released by the committee in a 44-page document, "Chemical, Biological, and Radiological Warfare Agents."

SATELLITES FOR WORLD COMMUNICATION

Rapid and spectacular advancements in the art of communications are expected within the next decade through the use of earth-orbiting satellites.

The interest of military services and commercial concerns in this country was readily apparent at the hearings held by the committee on March 3 and 4 on what may be the first real economic "payoff" of the new space age.

Various witnesses testified on the possibilities of using satellites for world communication.

They were:

Busignies, Dr. Henri G., president, ITT Laboratories, International Telephone & Telegraph Corp., Nutley, N.J.

Cortright, Edgar M., Chief, Advanced Technology Programs, Office of Space Flight Development, National Aeronautics and Space Administration.

Haley, Andrew G., president, International Astronautical Federation, and general counsel, American Rocket Society, Washington, D.C.

Haviland, Robert P., engineer, satellites, missile, and space vehicle department, General Electric Co., Philadelphia, Pa.

Johnson, Roy W., Director, Advanced Research Projects Agency, Department of Defense backed up by William H. Godel, Director of Policy and Planning, Advanced Research Projects Agency, Department of Defense; Paul A. Price, technical project officer, Communications Satellite Program, Advanced Research Projects Agency, Department of Defense, and Dr. Hans K. Ziegler, Director of Astro-electronics, Fort Monmouth Army Signal Corps Laboratory.

The hearings brought out that while the United States has no major problems in providing communication within this country, real and serious problems are involved in the use of conventional cable and

radio facilities for transoceanic communication and for radio communication to the polar regions.

Present facilities are overburdened and lack reliability because of atmospheric conditions or lack of network redundancy. The witnesses were convinced that unless new methods were sought the problems would become worse instead of better.

What then do earth-orbiting satellites offer in the way of improved communications? The possibilities appear to be very promising.

The idea of using a satellite as a communication relay device is not new. Shortly after World War II, in 1946, the possibility of using the moon as a worldwide communication relay was considered and technical papers were published on the subject. Again in 1955, one of the country's leading communication corporations undertook to study the possibilities of transoceanic communication using manmade satellites. Although most communication engineers knew little about the missile state-of-the-art at that time, they believed it would eventually be possible to place a communication satellite in orbit.

Communication satellites, as currently envisaged, will not replace existing communication networks but instead will provide a reliable and efficient means of spanning the oceans. Ground transmission and receiving stations will be tied into the existing networks. Simple devices capable of testing communication satellite theory are now available, and existing propulsion units can place such devices in orbit. Development work on a more advanced communication system employing a stabilized equatorial orbit can be completed within 4 years. Thus the possibility of making great improvement in worldwide communication is a most timely answer to an extremely pressing military problem and provides an intriguing opportunity for profitable expansion of service so far as civilian communication is concerned.

The military services and commercial concerns each have different requirements. The requirements to which the military program are tailored are stringent. For certain critical strategic intelligence information, or when command control at the national level is ininvolved, communication facilities must be capable of transmitting messages between the major command elements anywhere in the world in a matter of minutes, with assurance of complete reliability at all times. There must be every assurance of handling such critical traffic under conditions of interference or jamming, either natural or manmade. A program designed to facilitate all requirements for military communication satellites has been carefully prepared and is being actively pursued.

The first step in the overall program was Project Score, which successfully put a delayed communication repeater in orbit with an Atlas vehicle on December 18, 1958. This was a rudimentary form of device which will be improved greatly for later application in Project Courier. Development of this device in a form suitable for communication satellite use is scheduled for completion within 3 years.

Under the Courier concept, a satellite is placed in orbit at a relatively low altitude, approximately 500 miles, and as it passes over a ground station information previously stored in that ground station is transmitted rapidly to the satellite, where it is stored on a magnetic tape. As the satellite arrives at an area where it can be seen by the station to which the traffic is addressed, that receiving ground station

transmits a securely coded command to the satellite directing it to transmit the stored traffic. While the ground station is receiving messages stored within the satellite, it may also be transmitting, on a different frequency, traffic to be carried by the satellite to the other stations. By transmitting at extremely high rates during the short period that the satellite is in view of each station, it is possible to have a traffic-handling capacity equivalent to 20 teletype channels operating continuously at a rate of 100 words per minute. The first launching of a satellite testing the system capability under this program is planned to be within a year. As each Courier satellite goes into orbit it will be subjected first to a period of R. & D. testing, and then it will be made available for operational testing in order to obtain experience through actual usage. The development phase of this project is scheduled for completion in 3 years.

A classified project which is part of this overall military communication program is one to provide communication between ground points in the United States and aircraft in the polar regions. This project is currently being pursued as a matter of considerable urgency. A test launching to put a satellite in orbit for this purpose is to be accomplished within 2 years. All development work on the project is to be completed in 3 years.

A 24-hour equatorial real time active repeater appears to be the answer to rapid, reliable, military communication. A 24-hour equatorial satellite in an orbit 19,400 nautical miles (22,300 statute miles) from the surface of the earth travels at a speed such that the rotation of the earth keeps the satellite fixed with respect to any point on the earth. At this great distance a large portion of the earth's surface is radiovisible from the satellite. The satellite can thus act as a relay between points on the surface of the earth separated by several thousand miles. The instrumentation planned for this satellite will be heavier than that for earlier projects. It will also provide an increased communication capability—144 voice channels as compared to 20 teletype or 1 voice channel of the Courier type communication package. It will provide service on an instantaneous basis between the points being linked. In addition, it will have equipment for one voice channel for use to aircraft. The development schedule for this project provides for initial launching in a year and a half and completion of research and development in 4 years.

Several components of the 24-hour satellite system represent an effort of such magnitude as to become projects in themselves. One of these, the Centaur project, is intended to provide the high-energy upper stage essential to the program. Final full-test firings for this project are scheduled to begin in about 3 years. Another effort of considerably greater magnitude is the Saturn project, which will provide a 1,500,000-pound clustered booster, thus permitting ultimate use of the 10,000-pound payload. This large booster development project, initiated in August 1958, by the Advanced Research Projects Agency, will permit taking advantage of the greater payload capability by placing emphasis on long life, reliability, resistance to jamming, and total technical capability.

Ultimately the 24-hour equatorial satellite will become a building block to be employed in meeting the full military requirements for a global communication system. This system will consist of a network combining both equatorial and polar orbits. A network consisting of

both polar and equatorial orbit communication satellites having capabilities for relay from one to the other will meet all essential military communication requirements. Requirements, as they exist today, will take about 4 years for accomplishment. Completion of all equipment under development or planned for this program may take as long as 10 years.

The use of satellites for civilian requirements is being pursued by the Nation's civilian space agency, the National Aeronautics and Space Administration.

The NASA program is concerned primarily with the launching of passive communication satellites for research and development purposes. These satellites consist of aluminized Mylar balloons approximately 100 feet in diameter. Such a sphere weighing 150 pounds or less can be launched with existing rocket vehicles. The technique employed in a passive communication satellite system would be to track the sphere and to direct a narrow but powerful high-frequency radio signal at it. Approximately 98 percent of the energy impinging upon the sphere would be reflected and reach the earth as a very weak signal but covering a very large area. A ground station within this large area would be able to pick up the signal, provided the station included the very specialized tracking, receiving antenna and amplifying equipment required. While one such balloon satellite would provide communication between two earth stations for only a portion of the day, if there were enough satellites, communication could be provided up to approximately 98 to 99 percent of the time.

As a result of the testimony given the committee and other information obtained by the committee's staff the following conclusions were reached relative to the development of a satellite world communication system:

Communication within this country and in many of the more highly developed countries of the world is adequate and is capable of expansion to meet increasing need. Transoceanic communication and communication to the polar regions is inadequate in terms of traffic-handling capability, reliability, and versatility. Expansion of conventional transoceanic links is not keeping pace with the rising volume of messages.

One of the most serious deficiencies of existing transoceanic communication is lack of reliability. Radio links are extremely susceptible to interference from a wide variety of natural conditions, including electrical storms and distance from the Equator, as well as manmade interference. Cable links are subject to both accidental and deliberate rupture.

These inadequacies of the worldwide communication system can produce a slow, strangling effect in peacetime and a critically dangerous effect in time of emergency. Use of earth-orbiting radio repeaters offers an opportunity for secure, reliable military communication, resistant to deliberate interference by any enemy. Successful operation of military communication satellites will inevitably lead to highly profitable commercial exploitation.

Plans and programs of the Advanced Research Projects Agency of the Department of Defense have been prepared and are being actively pursued. Significant success has been achieved in critical steps of this military program and completion of the first

worldwide communication network based on the use of satellites for transoceanic links appears probable within the next 4 years.

Commercial applications in this field are proceeding at a more cautious pace. This is quite understandable since the feasibility of several possible technical approaches has yet to be demonstrated. Hardware will be designed and built to take advantage of the results of such investigations. Until these things are done the communication industry is in no position to expend large amounts of money in duplicating the efforts of Government agencies.

Ultimate success of the plans to integrate satellites into the worldwide communication system appears assured. Spectacular successes in the launching of large rockets and satellites and the successful placing of satellites in orbit in the past year have added measurably to this confidence. Other technological advances—of less spectacular nature but nevertheless of equal or greater significance—in the field of electronic devices have been achieved.

While highly commendable progress has been made toward the improvement of worldwide communication through the use of satellites, much remains to be done. There must be no letup of effort through lack of funds or indifference. The very existence of this country in large measure is dependent upon the success of these efforts.

The text of the hearings on this subject will be found in the committee's 122-page printed document, "Satellites for World Communication."

DISSEMINATION OF SCIENTIFIC INFORMATION

The mass of scientific information which is rapidly becoming available poses a problem to scientists whose progress is dependent to a great extent upon an interchange of ideas with colleagues abroad.

Many scientific journals are now being published in Russian, Chinese, and other Asiatic languages which are not understood by the majority of American scientists who in prior years were accustomed to relying upon periodicals printed in English, French, and German, languages common to many of them.

The problem of dissemination of scientific information, together with the translation of foreign scientific documents, is of ever-increasing importance in view of the rapidity with which present-day technological changes occur.

In an effort to focus attention upon the problems facing scientists and thus aid them in the solution of these problems the committee held a series of public hearings on May 25, 26, 28, June 2, and 17, at which the following witnesses appeared:

Conrad, G. Miles, president, accompanied by Raymond A. Jensen, executive secretary, National Federation of Science Abstracting and Indexing Services.

Farinholt, Dr. Larkin H., Deputy Science Adviser, Department of State.

Green, John C., Director of Technical Services, Department of Commerce.

Henkle, Dr. Herman H., John Crerar Library of Chicago.

Huff, Ben G., Director of Review and Services, Office of the Director, Defense Research and Engineering, OSD.

Knox, William T., director of technical information division, Esso Research & Engineering Co., Linden, N.J.

Mohrhardt, Foster E., Director, U.S. Department of Agriculture Library (National Library of Agriculture).

Mumford, Dr. L. Quincy, Librarian of Congress.

Rogers, Dr. Frank B., Director of the National Library of Medicine.

Waterman, Dr. Alan T., Director, National Science Foundation, accompanied by Burton W. Adkinson, Head, Office of Science Information Service, National Science Foundation, and Charles Ruttenberg, Assistant General Counsel.

It was emphasized at the hearings that greatly increased research effort without full knowledge of the work of others may be time-wasting and damaging to the scientist's reputation if his work lacks originality.

Perhaps the most important step that can be taken is to insure that basic research knowledge which has been generated throughout the world is made available promptly, accurately, and easily to American scientists and engineers.

Since the collection of Soviet and Chinese scientific papers appears to pose no real barrier, the dissemination of important scientific information to American scientists is hampered mainly by such things as physical separation, language, lack of publication media, and sheer volume of material produced.

The three largest repositories of scientific information in the United States are to be found in the Library of Congress, the National Library of Medicine, and the Department of Agriculture Library. Together they have a collection of more than 3½ million copies.

The committee was agreeably surprised by the disclosure that the Library of Congress exchanges publications regularly with 151 scientific and technological institutions in the Soviet Union alone. During the last fiscal year the Soviet Union provided 31,000 pieces in all fields of knowledge and the Library of Congress obtained still another 57,000 pieces from the Soviet Union through orders placed with 750 bookdealers throughout the world.

But the collection of scientific information does not stop with Government agencies. There are many contacts between individual scientists in this country and abroad which serve as avenues for the exchange of ideas, research results, and published documents. Furthermore, there are many private organizations engaged in the collection, indexing, and abstracting of scientific documents.

In the last few years, tremendous enthusiasm for mechanical translation of languages, using high-speed electronic computers, has sprung up in the United States, England, and the Soviet Union. However, results obtained so far cast considerable doubt on the possibility of attaining a fully automatic high-quality machine translation within the next 5 years. But this does not mean that machines cannot become highly useful mechanical aids to translation.

The most important step in the dissemination of scientific information is that of insuring easy access of this information to American scientists. Regional centers throughout the United States where complete science journal collections can be housed and serviced would be of great value.

On the basis of its study, the committee reached the following conclusions:

Basic research and new technology are the foundations of research and development effort on which we expend some $10 billion each year in the United States. This vast effort requires the discovery of new knowledge in the fundamental sciences at a very rapid rate. Years used to intervene between the generation of such knowledge and its application to the design and construction of useful materials and devices. Now the period is frequently measured in months. The United States has no monopoly on the generation of new scientific knowledge. New theories, valuable research results, and advanced technology are available in many parts of the world. If U.S. scientists are to keep abreast of world science and we, as a nation, are to retain leadership in science and technology, we must gather scientific information wherever it exists and make it available rapidly and in effective form to American scientists.

Under the provisions of the National Defense Education Act of 1958, the National Science Foundation has been given a great responsibility—that of providing or arranging for the provision of "indexing, abstracting, translating, and other services leading to a more effective dissemination of scientific information" and undertaking of "programs to develop new or improved methods, including mechanized systems, which make scientific information available." In discharging these responsibilities, the National Science Foundation coordinates its efforts with those of many other Government agencies, including the Library of Congress, the National Library of Medicine, the Department of Agriculture Library, the Office of Technical Services in the Department of Commerce, the Smithsonian Institution, and others engaged in the collection, exchange, and distribution of scientific information. Private indexing and abstracting organizations have been established to serve the particular needs of scientific groups.

The scientific information services rendered by many scientific societies and professional institutions to the scientific community are world famous for this quality. It is essential that the Federal Government continue to cooperate with and assist such private groups in the achievement of long-range solutions to scientific information problems.

The Library of Congress, Department of Agriculture Library, and the National Library of Medicine, when viewed collectively, constitute a national science library having holdings totaling more than 3½ million volumes. These collections are the most extensive in the world. Each of the libraries, in its field of interest, continues to add to its collection through purchase and exchange agreements throughout the world. While these great Government libraries and the large group of cooperating libraries throughout the country are doing a highly effective job, there is need for additional distribution centers for periodic journals.

The busy American scientist cannot begin to examine all the scientific literature available to him. If real value is to be gained from the large collections of science documents, means must be provided for the scientist to select in a minimum of time those

publications which are of value to him in his particular field. The mere publishing of lists of titles and authors is helpful, but most useful is the preparation of a short and accurate summary of each document. These abstracts can be prepared and distributed widely in a reasonably short period of time. This highly important effort should be given wholehearted support by both Government agencies and private organizations.

Before World War II, most of the world scientific literature was published in at least one of three languages: English, German, or French. A large number of our scientists are able to read both French and German; hence, but very little language barrier existed at that time. Since World War II, however, national traditions have restricted, generally, the publication of new scientific documents to the language of the country. Also since World War II, the quantity and quality of scientific papers published in Russian, Chinese, and the languages of other Eastern countries have greatly increased. Many Government agencies and private organizations throughout the country have undertaken the abstracting, and in some cases, the cover-to-cover translation of Soviet publications. Lack of funds has limited this effort insofar as Chinese and other Eastern literature is concerned. Additional funds must be found to support this essential service.

There are two highly important phases which are time consuming and costly in terms of money. As the volume of high-quality Russian, Chinese, and other Eastern language literature increases, the translating problem will increase. As the total quantity of scientific literature increases, the storage and retrieval problem becomes more complex. Costs of human services in the case of each are rising. Fortunately, translating, storage, and retrieval processes can be mechanized to some degree with great savings in time and money. There is need to continue the considerable research effort now being conducted into the use of high-speed electronic computers. We may never attain fully automatic, high-quality machine translation, but machines will certainly be used in the future to reduce human work greatly.

Efforts by members of this committee to amend existing legislation would permit highly useful employment of foreign currencies to collect, index, abstract, and translate foreign scientific documents abroad. This legislative change is important also from the standpoint of the encouragement given to friendly relationships and cooperative efforts between scientists in this country and abroad.

The transcript of the hearings on this subject has been printed and is available in the committee's 182-page document, "Dissemination of Scientific Information."

SPACE PROPULSION

On October 4, 1957, the Russians placed in orbit Sputnik I. According to the Soviet Union, it weighed 184 pounds. This was followed November 3 by Sputnik II, which was said to carry a payload of 1,120 pounds.

On January 31, 1958, the first American satellite was launched successfully by the Army. It weighed 30.8 pounds.

Foremost in the minds of the American public was the question: Why are the Russians able to place into orbit satellites of such greater weight (and consequently greater payload), than the United States? The answer soon became apparent. The United States lacked the necessary propulsion to propel larger bodies into space.

As recent as March 3, 1959, the American lunar shot (Pioneer IV), launched by the Army, carried a space capsule weighing only 13.4 pounds, compared with the 796 pounds of instruments, or 3,245 pounds of orbiting body, of the Soviet Mechta which the Russians reported they had sent into space 2 months earlier.

Since propulsion is the key to space exploration, the Committee on Science and Astronautics decided to hold exploratory hearings on the problems of space propulsion. The purpose was to provide itself and the lay public with a better understanding of the magnitude of the problems faced by the Nation.

As a result, hearings were held on March 16, 17, 18, 19, 20, and 23, at which the following witnesses appeared:

Bershader, Dr. Daniel, manager, gas dynamics department, Lockheed Missile and Space Division, Lockheed Aircraft Corp., Sunnyvale, Calif.

Biehl, Dr. Arthur, vice president and technical director, Aerojet-General Nucleonics Division, San Ramon, Calif.

Boden, Dr. Robert H., research specialist, Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif.

Carter, Dr. James M., corporate research adviser, Aerojet-General Corp., Azusa, Calif.

Coar, Richard J., chief engineer, Pratt & Whitney Aircraft Research Development Center, West Palm Beach, Fla.

Dixon, Thomas F., chief engineer, Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif.

Fthenakis, Emanuel, manager, navigation and controls engineering, Missile and Space Vehicle Department, General Electric Co., Philadelphia, Pa.

Geckler, Richard D., vice president, solid rocket plant, Aerojet-General Corp., Sacramento, Calif.

Giannini, Dr. Gabriel M., president, Giannini Plasmadyne Corp., and technical director, G. M. Giannini & Co., Inc., Santa Ana, Calif.

Godel, William H., Director, Policy and Planning, Advanced Research Projects Agency, Department of Defense.

Gunn, Dr. Stanley V., manager, nuclear propulsion projects, Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif.

Hoffman, Samuel K., vice president and general manager, Rocketdyne Division, North American Aviation, Inc., Canoga Park, Calif.

Johnson, Roy A., Director, Advanced Research Projects Agency, Department of Defense.

Kantrowitz, Dr. Arthur R., vice president of Avco Manufacturing Co., and director of Avco Research Laboratory, Everett, Mass.

Kimball, Hon. Dan A., former Secretary of the Navy, president, Aerojet General Corp., Washington, D.C.

Lee, Y. C., director of corporate research, Aerojet-General Corp., Azusa, Calif.

Longwell, Dr. John P., head, special projects unit, Esso Research & Engineering Co., Linden, N.J.

Martin, John M., general manager, explosives department, Hercules Powder Co., Wilmington, Del.

Newgard, John J., project engineer, nuclear propulsion, Reaction Motors Division, Thiokol Chemical Co., Denville, N.J.

Reid, J. A., executive vice president and general manager, Astrodyne, Inc., McGregor, Tex.

Reinhardt, William J., head, technical planning section, Reaction Motors Division, Thiokol Chemical Co., Denville, N.J.

Ritchey, Dr. Harold W., vice president and technical director, Rocket Division, Thiokol Chemical Co., Huntsville, Ala.

Rothrock, Addison M., scientist for propulsion, Office of Program Planning and Evaluation, National Aeronautics and Space Administration.

Seymour, Dr. Edward H., director of research, Reaction Motors Division, Thiokol Chemical Co., Denville, N.J.

Strough, Dr. Robert I., project engineer, CANEL, United Aircraft Corp., Middletown, Conn.

Thatcher, Albert G., manager, advanced engineering department, Reaction Motors Division, Thiokol Chemical Co., Denville, N.J.

Young, Robert B., vice president, liquid rocket plant, Aerojet-General Corp., Sacramento, Calif.

The witnesses represented various branches of the Federal Government, the military services, private industry, research institutes and universities. Their testimony provided a wealth of accurate, up-to-date technical information at a level understandable to the layman.

It also demonstrated that there is general agreement among the most eminent individuals in the field on what constitute essential elements of a space propulsion program.

The witnesses outlined in 307 pages of printed testimony the plans underway by the United States to help close the gap between the United States and the Soviet Union in propulsion, the propulsion methods currently employed, and various concepts, some still entirely visionary, which may open new frontiers in this field and bring about true space travel.

In the printed document, "Space Propulsion," issued by this committee will be found a thorough discussion of the various propulsion systems now in use or envisaged for the future. They include the use of chemical propellants, both liquid and solid, which will probably remain the backbone of the American propulsion effort for the next decade; nuclear propulsion, which may be achieved in 5 to 10 years; electrical propulsion, including ion and plasma engines, also quite possible within the next decade; and various exotic systems.

Space propulsion systems discussed under the heading of chemical, nuclear and electrical are either in operational or developmental use or have been demonstrated in principle in the laboratory. The search for better means of space propulsion does not stop with these more or less conventional ideas. Numerous proposals for more exotic systems have been advanced.

Included among the exotic systems discussed in the report is a propulsion system based upon the use of free radicals; the detonation of a series of small nuclear devices; solar sails and more complex

forms of photon propulsion; the use of antigravity or the creation of gravity screens; and the utilization of plasma or energy belts in space.

Based upon the testimony received by the committee and additional information gathered by the staff, the committee reached the following conclusions:

> * * * the problems of space propulsion now are being vigorously attacked in many aspects. In retrospect, some of these efforts began too late and, even now, some of the problems are so vaguely defined that we do not realize how much effort is required for solution. It is possible, then, that such problems may not be getting the kind of attention they deserve and require.
>
> With quite good reason, space propulsion programs can be divided into two categories, those which are achievable in the very near future—say 5 years—with the application of straightforward engineering techniques, and a second category in which we may merely see the problems better defined in 5 years and begin to see solutions in 10 years.
>
> In the case of the first grouping, there are vigorous and well-defined efforts on the part of the individual military services and the Department of Defense to improve the chemistry of liquid and solid propellants. Theoretically, improvements in the energy-carrying capabilities of chemical propellants can be as great as 50 percent. These programs must continue to be supported with great vigor because they represent the most tangible efforts we have to date of improving the fuels for space propulsion.
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> It is now obvious to all that had we instituted a strong program for the development of large rocket engines at the close of World War II when we had great but untapped capabilities, we would not now be in a position of second place to the U.S.S.R. so far as "weightlifting" capability is concerned. But this is past, and now we must do our best to make up for lost time. Saturn, an Advanced Research Projects Agency project for the development of a 1½-million-pound booster employing a cluster of existing and proven liquid rocket engines, is designed to give us a tremendously improved space capability within the next few years. It must be given full support if we are to maintain a balanced and yet increasing rate of effort in space activities. Anything less will keep us in a position inferior to the Soviets.
>
> Still another large rocket engine project is somewhat further off in time, but one which logically follows the Saturn project. This is the National Aeronautics and Space Administration development of a single chamber liquid rocket engine capable of producing 1 to 1½-million pounds of thrust. This project represents a reasonable extension of effort based upon experience we have gained with rocket engines produced for such missile programs as Atlas, Jupiter, Thor, and Titan. The NASA project is scheduled for completion in approximately 4 to 6 years. A test version has already produced over a million pounds of thrust, briefly. It will enable us to make another big jump in propulsion capability, because we can reasonably expect that this large engine will be formed into a cluster arrangement for a booster which will be capable of producing over 6 million pounds of thrust. This concept is employed in the proposed Project Nova system.
>
> With the increasing size and complexity, and above all, cost of the very large propulsion systems, it behooves us to practice every

reasonable economy. One such economy may be the development of techniques which will permit the recovery and reuse of large rocket engines, once they have performed their task and have been jettisoned. Investigations for several recovery techniques are currently underway and the results will be applied to some of our current programs.

One of the most immediate and pressing requirements is for the development of upper stage liquid rocket engines utilizing high energy propellants such as liquid oxygen and liquid hydrogen, or storable propellants. At least three such engines, ranging in thrust capability from 10,000 pounds to 300,000 pounds are a "must" if we are to make efficient use of the large boosters which exist today or are under development. It is possible, for example, to increase payload capabilities from 2 to 10 times merely by substituting high energy upper stage engines for those now used. The Advanced Research Projects Agency has in the past few months contracted for the development of a second stage engine of this type. The project, known as Centaur, was recently transferred to the National Aeronautics and Space Administration.

Nuclear propulsion and electrical propulsion fall into the second category, programs which are perhaps 10 years off in time, and are largely dependent upon how much progress we are able to make in research. One important aspect of this is research on materials. We know, for example, that pure metals, alloys, and ceramics which we have been able to devise permit operating temperatures on the order of 1,800° F. Nuclear reactors, if they are going to be efficient enough to carry into space, must be capable of material operating temperatures of approximately 2,500° F. and preferably 5,000° F. or more in order to gain efficiency. Compare this goal with the present capability of our earthbound nuclear powerplants which operate at less than 1,000° F. and in which, for the present, we are content to seek modest gains of 10 to 20 percent in performance. There are other problems in connection with materials, such as ability to withstand stress, effects of neutron bombardment on physical properties, and others; but this single example of temperature limitation points up a tremendous need for materials research. If there is one area of basic research which needs greater emphasis, it is perhaps this. Project Pontus of ARPA is one effort designed to solve some of these materials problems.

When we lick the research problem, nuclear reactors will provide us with a means of carrying heat energy into space; but we have other important energy needs. Electricity is needed for instrumentation, for guidance, for communication, and for propulsion. Simple, compact, reliable, lightweight electrical systems capable of producing up to 300 kilowatts of electricity continuously for a year or more simply do not exist. They must be brought into being before we can venture far into space and before we can devise truly efficient earth satellites such as we can now recognize a need for, and are developing for communication and weather purposes. At one end of the scale of electrical requirements where power needs are small, direct conversion from solar energy may be feasible. However, at the far end of the scale—300 kilowatts or more—conversion from the heat of a nuclear reactor is probably the answer.

It is difficult to maintain a proper perspective in the appraisal of the overall space propulsion program. The vast and exciting capabilities promised by nuclear, electric, and other exotic systems tend to color our thinking. It is too easy to forget that perhaps years of research, followed by development and extensive testing, are required before these new systems can reach the degree of reliability we have even now in our missile propulsion systems. Reliability cannot be bought with money alone. It is acquired and proven through experience. The years of research, development, testing, and the billions of dollars which have gone into guided missiles are now the most valuable asset of our national space program. Manned flight into space awaits only the refinement of reliability in these systems. If we are to make real progress in space exploration and use in the next several years we must stress component improvement and build bigger thrust units for space use based upon reasonable extensions of our missile propulsion system experience. Nuclear, electrical, and perhaps other systems seem assured, but are necessarily years into the future, particularly insofar as manned space flight is concerned.

Problems in the space propulsion field touch upon almost every aspect of science and technology. They range from conventional chemical combustion processes through advanced nuclear technology to unanswered questions on the formation of the universe. Their solution will not only give us the means to travel in space, but will improve and enrich our lives on earth.

THE GROUND-CUSHION PHENOMENON

The world may be entering a new phase of development in transportation based on a discovery which materially reduces the wasteful, retarding force of friction by allowing vehicles to roll on a cushion of air over land, sea, swamp, sand, or snow.

The ground-cushion phenomenon, as it is known, could revolutionize transportation, if successfully harnessed.

Enthusiasts envisage ocean liners traveling a few feet above the waves, vehicles traveling overland without benefit of roads, and trains scooting above monorails at speeds of 200 miles an hour.

Whether this will come true is too early to say, but it was apparent from the witnesses who testified on the subject before the committee that ground-effect machines potentially hold great promise for the future.

The committee, realizing the importance of such a development, held a series of public and closed hearings April 13, 14, and 15, to explore its status and possible future applications.

The following witnesses appeared:

Alper, William H., president, National Research Associates, Inc.; accompanied by Melville W. Beardsley, vice president, National Research Associates, Inc., and Paul Denn, Ordnance Tank Automotive Command.

Bennett, Rear Adm. Rawson, Chief of Naval Research.

Bollum, C. W., Sr., chairman of the board and president of Spacetronics, Inc.

Britton, Brig. Gen. F. H., Director of Developments, Office, Chief of Research and Development, U.S. Army.

Kucher, Dr. Andrew A., vice president, engineering and research, Ford Motor Co.; accompanied by David Jay, senior development engineer, Ford Motor Co.

Macauley, J. B., Deputy Director of Defense Research and Engineering.

Their testimony will be found in the committee's 77-page printed document, "The Ground-Cushion Phenomenon."

Both the civilian and military witnesses were united in expressing interest and optimism for the future uses to which vehicles employing the ground-cushion phenomenon may be put. Certain of the applications appear to be nearer at hand than others. However, it appeared obvious that more time and very probably a considerable amount of money will have to be devoted to research and development before some of the possible applications can be fully realized.

Looking toward the future, the committee reached these conclusions:

The ground-cushion phenomenon is not newly discovered. It has been known and investigated over a period of more than 20 years, but in a desultory fashion. Recently, research effort has been stimulated considerably. Theories have been advanced to account for the phenomenon and do so at least in part. The results obtained so far in unclassified work, while most encouraging, are largely experimental in nature. It remains to be determined whether present theories are completely valid when applied to the design of large-size machines and vehicles.

Department of Defense interest centers primarily around: (1) Vehicles which operate effectively either by ground-cushion effect or by aerodynamic lift; and (2) vehicles which operate by ground-cushion effect and which have limited conventional surface mobility. In the case of the first, as exemplified by the Avrocar project, the rate of effort and funding seem to be adequate at this time for the accomplishment of development objectives. If full development objectives are met, full-scale application will require greatly augmented funding support.

In the case of vehicles operating wholly within the ground cushion, Government direction to produce a coordinated effort has been lacking. A number of small efforts, meagerly financed and deriving little or no benefit from the work of others, has been the rule. The Department of Defense appears to have recognized this deficiency and is now proceeding on the basis of a more coordinated effort.

Several small civilian companies have also recognized the possibilities for utilization of vehicles operating wholly within the ground cushion, but have been limited by lack of personnel, research facilities and operating capital. Their efforts have been primarily in the experimental area and they have not been in a position to engage in extensive work on the development of theory. Even so, their efforts leading to the fabrication of demonstration models are commendable.

Of all the applications which can be freely discussed in this unclassified report, the air-bearing type of vehicle, such as has been proposed by the Ford Motor Co., appears closest to availability. Provided that the need can be shown to exist and funds are available, it appears possible to construct a high-speed monorail system with the knowledge now representing the current state-of-the-art.

The future can be bright indeed for this new means of transportation, for it enters the field at a time when our highways are clogged with truck and bus juggernauts and flooded with pleasure cars. The airways, with greatly expanding traffic, are daily becoming more dangerous. The railroads, while continuing to be efficient transporters of heavy freight, are too slow for our speeded-up tastes. Vehicles operating upon the ground-cushion effect may be an important answer to at least part of our civilian transportation problem.

Military uses range from combat and cargo vehicles operating a few feet above the surface to highly versatile reconnaissance or personnel-carrying vehicles capable of hovering a few feet above the surface or flying high and fast. The traditional foes of mobility—mud, swamp, sand, snow and Arctic tundra—need no longer prevent military operations and naval warfare may be revolutionized through use of high-speed above-water vessels.

The interest and optimism of both civilian and military leaders promise important progress in the near future.

STATUS OF MISSILE AND SPACE PROGRAMS

An extensive series of hearings was held by the Committee on Science and Astronautics on February 2, 3, 4, 5, 9, 10, 17, 18, 24, March 2 and 12 in order to provide a thorough review of the U.S. missile and space programs.

During the 22 sessions held by the committee, testimony was received from the following witnesses:

Anderson, Lt. Gen. Samuel E., commander, Air Research and Development Command, U.S. Air Force.

Barclay, Brig. Gen. John A., commander U.S. Army Ballistic Missile Agency.

Beach, Maj. Gen. Dwight E., Director, Air Defense and Special Weapons, Office of the Deputy Chief of Staff for Military Operations, Department of the Army.

Boushey, Brig. Gen. Homer A., Director of Advanced Technology, Office of Deputy Chief of Staff Development, U.S. Air Force.

Brucker, Hon. Wilber M., Secretary of the Army.

Campbell, Leon, moon watch program, Smithsonian Astrophysical Observatory, Cambridge, Mass.

Dick, Maj. Gen. W. W., Jr., Director, Special Weapons, Office of Chief of Research and Development, Department of the Army.

Donovan, Allen F., vice president and director, astrovehicles, Space Technology Laboratories, Inc., Los Angeles.

Dryden, Dr. Hugh L., Deputy Administrator, National Aeronautics and Space Administration.

Dulles, Hon. Allen W., Director, Central Intelligence Agency.

Gise, Lawrence P., Assistant Director (Administration), Advanced Research Projects Agency.

Glennan, Dr. T. Keith, Administrator, National Aeronautics and Space Administration.

Godel, William H., Director, Policy and Planning, Advanced Research Projects Agency.

Hagen, Dr. John P., Director, Vanguard Division, National Aeronautics and Space Administration.
Hayward, Rear Adm. John T., Assistant Chief of Naval Operations (Research and Development).
Holaday, William M., Director of Guided Missiles, Office of Secretary of Defense, and Chairman, Civilian-Military Liaison Committee, National Aeronautics and Space Administration.
Hynek, Dr. J. Allen, Associate Director, Smithsonian Astrophysical Observatory, Cambridge, Mass.
Johnson, Roy W., Director, Advanced Research Projects Agency, Department of Defense.
Lemnitzer, Gen. Lyman L., Vice Chief of Staff, U.S. Army.
Masterson, Rear Adm. K. S., Director, Guided Missile Division, Department of Defense.
McElroy, Hon. Neil H., Secretary of Defense.
Newell, Dr. Homer L., Jr., Assistant Director for Space Sciences, National Aeronautics and Space Administration.
Peters, Comdr. Irvin G., program manager, navigation satellite, Bureau of Ordnance, Department of the Navy.
Raborn, Rear Adm. W. F., Director, Special Projects Office, Department of the Navy.
Roadman, Col. Charles H., Chief of Human Factors Division, Directorate of Research and Development, Headquarters, U.S. Air Force.
Schriever, Maj. Gen., Bernard A., commander, Ballistic Missile Division, U.S. Air Force.
Siepert, Albert F., Director of Business Administration, National Aeronautics and Space Administration.
Silverstein, Dr. Abe, Director, Space and Flight Development, National Aeronautics and Space Administration.
Stewart, Dr. Homer Joe, Director of Planning and Evaluation, National Aeronautics and Space Administration.
Sydnor, Lt. Col. W. D., of Air Defense Division, in Director, Special Weapons, Office of Chief of Research and Development, Department of the Army.
Twining, Gen. Nathan F., Chairman, Joint Chiefs of Staff, Department of Defense.
Von Braun, Dr. Wernher, Director, Development Operations Division, Army Ballistic Missile Agency, Huntsville, Ala.
Wagner, Capt. E. O., Coordinator of Missile Ranges, Office of Deputy Chief of Naval Operations (Air).
White, Gen. Thomas D., Chief of Staff, U.S., Air Force.
Wyatt, DeMarquis D., Assistant to the Director of Space Flight Development, National Aeronautics and Space Administration.
York, Dr. Herbert F., Director of Defense Research and Engineering, Department of Defense.

The hearings were incorporated in a 492-page volume entitled "Missile Development and Space Sciences."

From the hearings, the committee arrived at these conclusions:

1. The real source of confusion over our technical posture apparently relates to matters of time. Different estimates of how soon free world and Soviet bloc countries will have operational long-range missiles and will attain certain space objectives lead to the contradictory views which the public hears.

2. The committee is convinced from its studies that whatever the current situation is, radical technological advances on both sides of the Iron Curtain are approaching at such a headlong pace that for planning the life of the Nation it must be recognized as virtually upon us. A few years at most will bring new weapons and new space capabilities for exploration and for utilization which must make profound alterations in our ideas and our strategy.

3. It is not possible to state with certainty whether the balance will lie with the offensive or the defensive capabilities emerging from this new technology. In general, offensive powers seem greater for the next few years than any wholly successful countermeasures. This in turn affects judgments as to the dangers to civilization everywhere, and also influences views on the nature of deterrent forces.

4. This committee concludes that no one can give final answers as to the exact timetables by which the United States and the Soviet Union, in particular, will complete the development-to-operational status of their respective weapons systems and defenses. Nor is there any clue that the day can be foreseen when there will not always be more sophisticated and versatile systems coming along, demanding heavy outlays of national resources and manpower. Without picking particular years, the committee does recognize that some of the new weapons can conceivably be so decisive that there will be periods of great danger when strength may lie so much on one side as to tempt strategic planners to try to destroy much of the potential of the opponent.

5. It is an art requiring very high skill to decide what balance in the use of resources and manpower will meet both the long-range risks and the short-term threats resulting from an imbalance of power. This committee is not charged with direct responsibility for settling differences over the size of the total national budget of which defense is the larger part. What it does note, within the framework of its responsibilities, is that there is no place for lopsided concern with either short-run or long-run problems of technology and defense. Any failure to adjust our needs to long-run requirements for supporting basic research and maintaining a viable economy would be a source of great danger in this age of long leadtimes. Likewise any failure to recognize short-term dangers of imbalance would run the risk that this Nation might have no future to worry about.

6. Every branch of the armed services, and all the departments of Government concerned with science, technology, and defense, are properly cognizant of our needs. They have dedicated leaders and staffs working hard to meet these challenges. They also have the means to coordinate their efforts, which are used with varying degrees of success. Many face acute problems of obtaining the budget support to do the job as well as they would like.

7. The United States is making excellent progress in visualizing its technical needs, and in shaping weapons systems. Full credit should be given to those responsible for these accomplishments. There is nothing inconsistent with this praise in also recognizing how great the need is for even more accomplishment. Indeed, we cannot afford the luxury of satisfaction, and no leader in

Government or the military who appeared before this committee showed satisfaction with his accomplishments or with the resources he is able to command. This is quite an important point, for words are sufficiently inexact so that an occasional witness seemed to differ from this generalized conclusion. But in fact, the exceptions turned on qualifications which emerged in cross-examination. Particularly in the case of the NASA, the Administrator appeared satisfied with his funding, yet his view seemed tempered by shortages of trained personnel and the newness of the NASA operation.

8. Individual members of this committee were impressed in varying degree with needs for greater funding of particular service projects. The committee as a whole recognizes that some of the most desirable of the underfunded projects cannot be ready in time to meet some immediately pressing problems, but also that our thinking must reach ahead a decade and more, and our plans made accordingly. The committee also recognizes that for whatever reason, the public at large either does not yet appreciate the urgency of the times, or for other reasons is not prepared to make the sacrifices of reduced Government services, higher taxes, greater effort or productivity, or more inflation which in some combination would be required to pursue today all the alternative defense and science paths open to us. In the future, if the economy continues to grow, more such paths may be pursuable without as much cost to the routine of normal living.

9. The committee recognizes that neither it nor the Congress can make all the technical judgments involved in choosing among weapons systems or other technical projects. But it is equally impressed that such decisions affect all of us so deeply that the people as a whole, at least through their elected representatives, must participate to the fullest extent possible. The technicians and the military can lay out alternatives, but frequently final choices are too heavy a burden for the Secretary of Defense or the President to make without the full support and understanding of the Nation.

10. The recent hearings by the Committee on Science and Astronautics, if studied by the Congress and by the public, can provide important inputs for public understanding of some of the gravest issues of our times.

U.S. POLICY ON THE CONTROL AND USE OF OUTER SPACE

With the advent of the space age, the world has come face to face with an entirely new problem. Simply stated, it is this: Who controls outer space? Where does international law begin and where does it end once man leaves the confines of the earth?

In an effort to cope with this problem, the United Nations established an Ad Hoc Committee on the Peaceful Use of Outer Space. It was anticipated that this group would be followed by a permanent Space Committee whose task will probably be to work out some modus vivendi that will insure the peaceful exploration and use of outer space and the planets of the solar system.

The importance of this is self-evident, for if man's activities in space are not regulated to some extent by international agreement and law, anarchy in space will grow. Sooner or later dangerous conflict would almost certainly result.

In order to focus attention on the problem and to explore the position taken by this country, the Committee on Science and Astronautics held public hearings March 5, 6, and 11 during which it heard the following witnesses:

Becker, Loftus, Legal Adviser, Department of State.

Durant, Frederick C., III, AVCO Research Laboratory, Everett, Mass.

Feldman, George J., former director and chief counsel, Select Committee on Astronautics and Space Exploration.

Johnson, John A., General Counsel, National Aeronautics and Space Administration.

Keating, Kenneth B., Senator from the State of New York.

Ward, Rear Adm. Chester, Judge Advocate General, U.S. Navy.

Wilcox, Hon. Francis, Assistant Secretary of State for International Organization Affairs.

Their testimony will be found in the committee's 108-page document, "International Control of Outer Space."

From the hearings and investigations conducted by the committee and its staff, it is possible to draw certain reasonably firm conclusions in regard to the trends of contemporary thinking on the international control of human activities in space.

These conclusions may be summarized as follows:

(1) Authoritative opinion, within the Government and outside it, is now closer to unanimity in advocating prompt efforts to begin the formulation of at least some international principles of conduct for the use of space beyond the definable atmosphere. This view, however, takes account of the caveat that the United States and the free world, through international agreement, may unduly restrict their space operations while the Communist world does not.

(2) The present state of international law is not sufficiently developed to cover problems of space, and in many cases its seemingly analogous principles would be inappropriate. This means that a fresh approach is necessary.

(3) Early efforts to develop such an approach should not involve the attempted formulation of a detailed code. Too little is known about space at the present time to permit any true codification of space law.

(4) In considering and discussing with other countries a means for controlling the use of space, better results may be expected if national representatives initially avoid matters which are akin to disarmament, such as inspection plans or agreements attempting to define or control military space vehicles. Experience indicates that the disarmament nut is still too tough to crack. The peaceful development of space would not be served simply by shifting this argument from one locale to another.

(5) The most likely area for a beginning process of space control is the commercial and scientific uses of space.

(6) Efforts to explore means of space control need not be limited to activities at the United Nations level. Effective use may also be made of such private organizations as the International Council of Scientific Unions, the International Astronautical Federation, the International Law Association, and their member organizations. These and similar groups should be encouraged to cooperate with the United Nations and vice versa.

(7) It is feasible for the other member nations of the United Nations Ad Hoc Committee on the Peaceful Use of Outer Space to proceed with their work minus the Communist bloc members if the latter cannot be persuaded to participate. Recent history suggests the Soviets and their satellites, whether or not they help initiate the rules, may go along with agreements observed by a large enough majority of nations. Witnesses testified that the Soviets have done this in the case of territorial ownership in the Antarctic, in the case of the international atomic energy program, and in the general observance of flight law as promulgated by the Convention of International Civil Aviation although they have never became a party to that treaty.

In conclusion, the committee concurred with John A. Johnson, General Counsel of the National Aeronautics and Space Administration, when he said:

> Unless collective steps are taken to subject the exploitation of outer space to an orderly restraint, it is quite probable that fear, rather than hope, will dominate man's attitude toward these amazing new developments, and that national security, rather than scientific advance and the economic benefit of mankind, will keynote every new effort. It is the task of law and international organization to prevent such a disaster.

NUCLEAR EXPLOSIONS IN SPACE

In the spring of 1959, the Department of Defense confirmed the news that the United States had conducted experiments the previous summer in outer space with nuclear weapons to explore the many possible phenomena that might accompany such explosions. The experiments were known as Project Argus.

News of the project first came in irregular fashion through unofficial sources and included much speculation of doubtful accuracy. The Committee on Science and Astronautics therefore requested a closed-door briefing by the officials in charge. This hearing was held April 10. Testifying at this hearing were Dr. Herbert F. York, Director of Defense Research and Engineering for the Department of Defense, and Dr. Frank Shelton, Technical Director of the Armed Forces Special Weapons Project.

Following the deletion of classified material by the Department of Defense, the testimony was released by the committee in a 24-page document entitled "Nuclear Explosions in Space."

Impetus for the test was provided by Nicholas C. Christofilos on the basis of experimental work on controlled thermonuclear power at Livermore, Calif. Christofilos theorized that if electrons were inserted into the magnetic field of the earth at the right place, they

would first travel along magnetic lines of force in a spiral path, then as they approach the zone toward the magnetic pole where these lines of magnetic force converge, they would reverse their general direction of movement, and go back to the mirror point in the opposite hemisphere. This process would repeat, in effect keeping the electrons oscillating along the horseshoe-shaped magnetic lines. Christofilos further believed these electrons would spread so as to ring the earth in the form of a cylinder or shell. A source of high-energy electrons might thus be provided by a nuclear explosion in space. It was not known in advance how intense the umbrella of electrons would be, or how long the effects would persist.

The project was approached with caution, using very low-yield nuclear weapons, so that no serious problems of fallout or other unexpected results might follow. On the one hand, the experiment represented pure science on a grand scale, potentially capable of contributing much fundamental knowledge on geophysics, force fields, radiant energy and particle behavior. On the other hand, there was the possibility that the experiment might have considerable military significance. The electrons in the shell could conceivable become a radiation hazard to future manned satellites in orbit around the earth. They might also have profound effects on the use of radio communications.

The details of the experiment are fully discussed in the printed hearings and House Report No. 575 which accompanied it and will not be gone into detail here.

However, these conclusions may be noted:

> Project Argus is symbolic of the stirring times in which we live. On the one hand, it was a boldly conceived experiment in pure science of immense geophysical proportions, labeled by some publicists as the greatest scientific experiment in all history. On the other hand, it had to be conducted as a secret military operation because it involved a host of questions which might affect the balance of military power in the new technologies of missiles and space travel.
>
> In a sense the results were mostly scientific, and the military results were somewhat negative. There has been no announcement that any really compelling military consequences can be foreseen from the experiments that in any way live up to public speculation about nuclear weapons in space. Laymen have wondered whether nuclear weapons in space would create a shell of sufficient intensity as to make manned satellites impractical. They have also wondered whether the intensity of such radiation could in any way create an umbrella of protection against incoming ICBM's, or whether the nuclear warheads of such missiles would be "cooked" to explode prematurely. They have wondered whether radar would be so interfered with as to change the antimissile defense outlook. But the only positive potential military effect which has been acknowledged by the experts relates to local interference with communications through the creation of artificial auroras.
>
> On the other hand, further drama surrounds the Argus test because of its close link with the broader question of international control of nuclear testing, and the possibilities

of detecting such tests wherever they occur. Surface tests have been thought the easiest to detect. Underground blasts are believed by some to be always traceable, and by others to afford a degree of privacy. Now the question of detection of tests in outer space is presented.

Is there a case for continuing experiments with nuclear weapons outside the earth's atmosphere? What fallout problems, if any, are presented? What international concern should be shown for any proposal to explode a nuclear weapon on the moon as a way of signaling arrival of a rocket and also as a means for testing the surface, and possibly for catching debris with an orbiting manmade satellite of the moon for return to earth? What of recent proposals for firing a thermonuclear weapon many millions of miles away from the earth as a way of testing the validity of some accepted theories of relativity? What should be done about new proposals to lift a space station weighing thousands of tons through a series of nuclear explosions? What tests should be considered military, and what scientific? What are the places of unilateral national action in such tests, and where must international cooperation be the rule?

Argus has perhaps raised as many questions as it has answered. It is likely not the last word which will be spoken in the area of imaginative experiments on the grand scale. With the rapid improvements expected in man's space capabilities, nuclear energy is certain to play an important part.

SCIENTIFIC MANPOWER AND EDUCATION

Deficiencies in the Tabulation and Study of Manpower

On February 25, 1959, the Committee on Science and Astronautics began a series of hearings to acquaint members with the status, needs, and problems of the Nation's scientific manpower and education complex.

The hearings were extensive, running intermittently through May 1959. More than 30 expert witnesses appeared.

At that juncture the committee paused to evaluate the information presented to it and, on the basis of testimony thus far received, one major area of the scientific manpower problem appeared to warrant immediate attention. This was the problem of keeping track of the Nation's scientific and technical personnel, of knowing who these people are, where they are, what they can do. The hearings had disclosed that there is no place nor any organization which has comprehensive up-to-date information covering all scientific and technical personnel.

Consequently, the committee held additional hearings in June, inquiring further into current programs for tabulating and studying the scientific and technical manpower of the United States. Additional witnesses, specialists on the subject under inquiry, appeared before the committee; additional information was filed with the committee staff; reports on the subject which had been conducted by other groups in the near past, official and semiofficial, were studied.

It became clear to the committee that the Government's present efforts to create a useful census of scientists, engineers, and techni-

cians—efforts being coordinated by the National Science Foundation under its 1950 charter—needed a substantial boost.

The chairman of the committee thus introduced on June 26, 1959, H.R. 7981, a bill which would have provided for a special ad hoc interdepartmental committee in the executive branch to review the entire problem and report its findings and recommendations back to the Congress. However, at a meeting of the committee on August 6, 1959, it was decided that a more immediate approach should be followed. The committee approved a resolution requesting the National Science Foundation to consult with all executive agencies concerned with the matter and report its findings and recommendations back to the committee by the beginning of the 2d session of the 86th Congress in January 1960.

In approving this resolution the committee found that—

the National Science Foundation's enabling act required it to keep track of *all* scientific and technical personnel in the United States;

studies of the problem existing to date were not adequate to advise the committee of what further legislation might be needed;

the Foundation's operation of its manpower program was unduly conservative;

the Foundation itself is dissatisfied with its manpower program;

the program cannot presently provide the information which Congress intended to be available;

the need for the tabulation and study of scientific manpower is greater today than ever before.

The committee recommended—

(1) That the executive branch of the Federal Government, as a whole, lend its aid and influence to help assure that the study requested by the committee, for submission by the opening of the next session of the Congress, will contain all relevant views and indicate where legislative action may be of most value.

(2) That the National Science Foundation seriously and carefully scrutinize its total mission, budget, and organizational structure to ascertain if more emphasis may not profitably be given to its scientific manpower programs.

(3) That the National Science Foundation and its advisory groups not permit themselves to be overly deterred from prompt and vigorous action by the shifting scientific scene. Events of the past decade indicate that this situation will not only continue but become more acute. The objectives of the manpower program and the means of reaching them should be decided upon forthwith, even at the risk of some mistakes, and immediate steps taken to implement.

Conclusion

The committee acknowledged that in this complex matter it does not have sufficient information or background to make more specific recommendations or sponsor helpful legislation at the present time. The committee is not now critical, nor does it wish to appear so, of the conduct of the manpower programs within the administrative limitations imposed upon them. The committee does believe that the programs have been unduly slow in developing. It is the hope and

intent of the committee, by its action here, to encourage and promote all appropriate Government agencies in their efforts to improve surveillance of the Nation's scientific and technical manpower.

During the course of the hearings, the following witnesses appeared:

Armsby, Henry, U.S. Officer of Education.

Bethel, Dr. James S., program head, special projects in science education, National Science Foundation.

Carleton, Robert H., executive secretary, National Science Teachers Association, accompanied by Dr. Herbert A. Smith, president, National Science Teachers Association, and Chief, Science, Mathematics, and Modern Foreign Languages, Office of Education, Health, Education, and Welfare.

Derthick, Dr. Lawrence, Commissioner, Office of Education, Department of Health, Education, and Welfare, accompanied by Dr. Robert Hamlin, assistant to the Secretary of HEW, Dr. Roy M. Hall, Assistant Commissioner; Ralph C. M. Flynt, Assistant Commissioner, Legislative Services Branch; Charles W. Radcliffe, Administrative Officer, Legislative Services Branch; Clarence B. Lindquist, specialist, Science and Mathematics Division of Higher Education; John R. Ludington, Director, Aid to State and Local Schools Branch; Ellsworth S. Obourn, specialist, science education, Secondary Schools Section; Kenneth E. Brown, specialist, mathematics education, Secondary Schools Section; James H. Pearson, Assistant Commissioner for Vocational Education; Lynn Emerson, consultant, area vocational education programs; Herbert S. Conrad, Director, Educational Statistics Branch; John W. Asher, Research Coordinator, Cooperative Research Branch; Dr. Van Slyke, Deputy Director, NIH; and Dr. James Shannon, Director of the National Institutes of Health.

Douglass, William A., president, Careers, Inc.

Eckler, Ross A., Deputy Director, Bureau of the Census.

Fontaine, Dr. Thomas D., program head, fellowship, National Science Foundation.

Gamble, Dr. Allen O., Chief, Examinations and Standards Division, National Aeronautics and Space Administration.

Haenisch, Dr. Edward L., program head on institute programs, National Science Foundation.

Hennessy, James, Executive Assistant to the Commissioner of the Bureau of Immigration and Naturalization.

Horne, Rear Adm. Charles F., U.S. Navy, retired; vice president and division manager, Convair, Pomona, Calif., and chairman, Southern California Industry-Education Council.

Kelly, Dr. Harry C., Assistant Director for Scientific Personnel and Education, accompanied by Dr. Bowen C. Dees, Deputy Assistant Director for Scientific Personnel and Education; Thomas J. Mills, Program Director for Scientific Manpower; and C. B. Ruttenberg, Assistant General Counsel, National Science Foundation.

Kelly, Dr. Harry C., Assistant Director for Scientific Personnel and Education, National Science Foundation.

O'Brien, James C., Director of Personnel, U.S. Department of Health, Education, and Welfare.

Rickover, Vice Adm. H. G., Assistant Chief of Bureau for Nuclear Propulsion, Navy Bureau of Ships.

Roe, Dr. Arthur S., program head, course content improvement, National Science Foundation.
Trytten, Dr. M. H., Director, Office of Scientific Personnel, National Research Council and National Academy of Sciences.
Waterman, Dr. Alan T., Director, National Science Foundation.
Whaley, Dr. Randall M., director, Advisory Committee on Education, National Academy of Sciences.
Wolfle, Dael, executive officer, American Association for the Advancement of Science.

The committee's proceedings will be found in the 847-page printed documents, "Scientific Manpower and Education" (pts. I and II).

THE FIRST SOVIET MOON ROCKET

Introduction

At one time it was the popular view, while recognizing the importance of science abstractly, that in American circumstances scientific progress could take care of itself.

This situation has now changed fundamentally.

Soviet technical accomplishments, particularly in astronautics and nuclear weapons, pose an early threat to our survival.

Soviet Technological Accomplishments

The Soviet Union has presented to the world a record of accomplishment across a broad front, arranging the facts or the appearances to maximize their impact on both their own people and upon the uncommitted or free world nations.

The Soviet economy is growing at a rate higher than that of the more advanced countries.

Soviet education represents a second field where impressive results have been obtained. Such an effort is being made, particularly in science and engineering, that another 10 years of the same trends in both countries will give the Soviet Union a distinct advantage over the United States in numbers of technically trained people.

Soviet science has many successes to show the rest of the world. Soviet scientists have a very large number of institutes and a large output of scientific journals and literature. They are doing good work in high energy physics, including the operation of the 10 billion volt accelerator at Dubna. They do good work in radar and electronics and optics. Their research in materials is impressive. Many Soviet facilities still seem crude and backward by our standards. But the Soviet Government uses all the resources of a police state to comb the whole world for information, and then makes it available in translation promptly to their technical people. The combined effect of all these efforts in net balance represents a formidable accomplishment.

This report has been deliberately kept within manageable limits by concerning itself primarily with Soviet space technology. It is evident that the most careful attention has been paid by the Soviet leaders to political and psychological effects. Nevertheless, Soviet propaganda claims in the field of astronautics are apparently based on solid achievements; otherwise they would run the risk of serious whiplash effects if disproved.

After World War II, the Soviet Government decided very promptly to pursue ballistic rocketry to continue the Russian tradition of rocket development.

During the same period, the best technical advice in the United States was that very big warheads would prove too expensive to deliver by missile; and our own work consequently ran at a low level of support until the new, small warheads were developed. As a result, our military boosters afford only a moderate capability to put weight into orbit, while the Soviet capability derived from military missiles is somewhat greater.

Let us review in brief the claimed Soviet accomplishments:

Orbiting vehicles

Oct. 4, 1957	Sputnik I—184 pounds of instruments—orbit between 142 and 588 miles above Earth.
Nov. 3, 1957	Sputnik II—1,120 pounds of instruments—orbit between 140 and 1,038 miles above Earth.
May 15, 1958	Sputnik III—2,134 pounds of instruments in a 2,925-pound capsule—orbit between 135 and 1,167 miles above Earth.
Jan. 2, 1959	Lunik or Mechta—796 pounds of instruments in a 3,245-pound capsule—orbit around the Sun after passing within 3,700 miles of the Moon.

Sounding vehicles

Feb. 21, 1958	Geophysical laboratory, with 3,000 pounds of instruments, sent 294 miles up.
Aug. 27, 1958	Dogs and instruments, weighing 3,718 pounds, sent 281 miles up.
July 2, 1959	Dogs and instruments, weighing 4,400 pounds, sent about 300 miles up.
July 10, 1959	Dogs and instruments, weighing 4,840 pounds, sent about 300 miles up.

These accomplishments are technically to be expected of a nation which started serious work on ballistic rockets at an early date and built large boosters.

The Soviet Moon Rocket

On January 2, 1959, Soviet space technology again became a subject of lively public debate. The Soviet Union announced that it had launched a 3,245-pound rocket with a payload of 796 pounds on its way toward the Moon. Still later, Soviet sources said that the rocket had missed the Moon by 4,700 miles or so (they quickly lowered the estimate to 3,700 miles), and gone into orbit around the Sun.

As time passed, however, it became evident that the event was reported almost exclusively by Soviet and other Communist sources, without much independent verification.

The Committee on Science and Astronautics has felt a public responsibility to investigate the evidence for and against the authenticity of the Soviet launching and its probable results.

During the evening of January 2, 1959, the Soviet Home Service Radio announced that on that day:

> * * * a cosmic rocket was launched toward the Moon in the U.S.S.R.

The final stage contained instruments for measuring the Moon's magnetic field and radioactivity, cosmic rays, protons and heavy nuclei in cosmic radiation, interplanetary gases, corpuscular solar radiation and meteoric particles. It also contained radio transmitters broadcasting on three frequencies (19.993, 19.995, and 19.997 megacycles) of approximately 20 megacycles and a fourth frequency of 183.6 megacycles. Two pounds of sodium released at a distance of approximately 70,000 miles from the Earth formed an "artificial comet," visible from the Earth as a sixth magnitude star in the constellation of Virgo.

The final stage carried pennants with the coat of arms of the Soviet Union and the inscription "Union of Soviet Socialist Republics. January—1959—January." In addition, it contained a steel sphere with similar inscriptions.

According to Soviet sources, the radio transmitters and scientific instruments worked normally and reliably. Radio signals from the rocket were received in the U.S.S.R. and other countries of the Soviet bloc. The time taken to reach the vicinity of the Moon was about 35 hours. After passing the Moon at a distance of about 3,700 miles, the rocket continued its flight as a new member of the solar system, in orbit around the Sun.

At first the Soviet Moon rocket was popularly called "Lunik" (i.e., moon satellite). Its name was later changed to "Mechta" ("dream").

Ten hearings, both public and executive, were held on the Soviet Moon rocket and related Soviet technology by the full committee and a special subcommittee. While much of the evidence on both subjects is classified, the rest of this report summarizes the salient testimony as far as possible, and presents the findings which flow from the evidence as a whole.

Hearings were held on May 11, 12, 13, 14, 28, and 29. The following witnesses were heard:

Benham, Dr. Thomas A., professor of physics, Haverford College.

Curtis, Dr. Harold O., Chief of Operations Branch, Project Space Track, U.S. Air Force Cambridge Research Center, Bedford, Mass.

Daigh, Ralph, vice president and editorial director, Fawcett Publications.

Dryden, Dr. Hugh L., Deputy Administrator, National Aeronautics and Space Administration.

Fox, Lt. Col. James H., USAF, member of Air Technical Intelligence, Wright-Patterson Air Force Base.

Godel, William H., Director, Policy and Planning Division, Advanced Research Projects Agency.

Hall, Col. Linscott A., USAF, Deputy Director of Estimates, Office, Assistant Chief of Staff, Intelligence.

Mallan, Lloyd, science writer.

Morris, Capt. Jack, USAF, Office of Air Force Intelligence.

Pickering, Dr. W. H., director, Jet Propulsion Laboratory, Pasadena, Calif.

Shapley, Dr. Alan H., Assistant Chief of the Radio Propagation Physics Division of the National Bureau of Standards, Boulder Laboratories, Boulder, Colo.

Singer, Dr. S. Fred, associate professor of physics, University of Maryland.

Slavin, R. M., Director, Project Space Track, Air Force Cambridge Research Center, Bedford, Mass.

Stewart, Dr. Homer J., Director of Planning and Evaluation, National Aeronautics and Space Administration.

Ziegler, Dr. Hans K., Assistant Director of Research, U.S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J.

The first witness was Lloyd Mallan. In essence, his argument was, first, that virtually all our information about the Soviet Moon rocket came from Soviet sources and that free-world confirmation was scanty, at best; and, secondly, that the Soviet Union lacked the scientific and engineering competence required for such an achievement.

As to independent evidence of the Soviet Moon rocket, Mallan stated that, if such a shot had been made, the radio signals transmitted by the rocket would probably have been detected by the tracking equipment at Jodrell Bank (in England), Goldstone (operated by the Jet Propulsion Laboratory of the California Institute of Technology), and Menlo Park (operated by the Stanford Research Institute) and by various U.S. military installations. As to Soviet space technology, Mallan described the guidance systems, tracking cameras and the like which he saw in the Soviet Union as "primitive" and "old hat."

The radio signals received by U.S. stations on January 3 and 4 on the frequencies announced by the Soviet Union constitute a major body of evidence bearing on the authenticity of Lunik. According to R.M. Slavin, the Director of Project Space Track, U.S. Air Force, messages were sent on January 2 to all cooperating stations, listing the announced frequencies and requesting that they be monitored. As a result, many reports were received. Only two, however, contained tracking data; these were the reports from the Jet Propulsion Laboratory (Goldstone) and from the Stanford Research Institute.

At about 3 a.m. on January 4, the Goldstone station detected signals on 183.6 megacycles, and tracked an object to the west of (and moving away from) the Moon. Dr. Pickering said there was no doubt in his mind that the object being tracked was the Soviet Moon rocket.

During the same night, the large radiotelescope at Jodrell Bank in England also searched in the vicinity of the Moon over a frequency band covering 183.6 megacycles, but failed to receive any signals. It is very difficult, however, to detect and track a given frequency on short notice. Furthermore, it is possible that the signals were turned off except when the Moon rocket was visible from the Soviet Union.

The Stanford Research Institute was also notified on January 2 that a Soviet Moon probe had been launched. On January 3, it began monitoring 19.993, 19.995, and 19.997 megacycles. Signals were first received at about 1045 (universal time), and were recorded on magnetic tape for about 45 minutes.

Signals on the same frequencies were also received by the Army Signal Corps Station at Fort Monmouth, N.J.

Another body of evidence bearing on the authenticity of Lunik is the publication in the Soviet Union of information supposedly obtained by Lunik during its flight to the Moon. This information was first published in Pravda on March 6 and then, in greater detail, on April 11 in the "Reports" of the Soviet Academy of Sciences.

Most of the witnesses stated, with varying degrees of assurance and cogency, that they believed the Soviet Union had indeed, as it announced, sent a rocket to the vicinity of the Moon. Some doubts, however, were expressed as to how far the rocket went or how close it came to the Moon.

There is some evidence that Lunik was intended to hit the Moon, and not merely to pass it at close range.

As far as the committee could determine, no photographic evidence of Lunik is available in the free world.

Considerable testimony was elicited on Soviet space technology in general. For example, Col. Linscott A. Hall, of Air Force Intelligence, stated that—

> * * * the United States probably still has a way to go, in order to catch up with the Soviets in terms of guidance and propulsion, which are the two major factors in the missile field.

Professor Singer commented, however, that it is not possible to judge the accuracy of Soviet guidance, since the Soviet Union did not announce the orbits of its satellites or the trajectory of its Moon rocket in advance.

As to the miniaturization of electronic components by the Soviet Union, all the witnesses agreed that miniaturization is unnecessary if very powerful rockets are used.

Summary

Reception of signals on announced Lunik frequencies

The Soviet Union announced that Lunik would transmit on four frequencies. A number of stations in the United States and some in other Western countries received signals on one or more of the announced frequencies at the indicated time. It is true that very little tracking information was obtained; in fact, the only tracking information that has been publicly released (obtained by the Goldstone Station) is very rough and scanty. Nevertheless, it would have been extremely difficult for the Soviet Union to simulate the signals that were received. Qualified witnesses testified that such simulation would have been a technical achievement at least as great as sending a rocket to the Moon. The possibility that radio signals from Jupiter, television broadcasts or the like, were mistaken for Lunik signals has been eliminated beyond a reasonable doubt.

Soviet space technology

After the sputniks, there is no serious question that the Soviet Union could have developed sufficiently powerful propulsion systems to send a rocket to the Moon.

Without knowing the intended trajectory, it is not possible to judge the accuracy of the guidance system used in the Soviet Moon rocket. Assuming that the rocket was intended to hit the Moon, a miss of several thousand miles would indicate a high degree of accuracy, though not high enough for an ICBM. On the other hand, no one in the non-Communist world can verify that the Soviet Moon rocket came within 10,000 miles or more of the Moon. The closeness of the sputnik perigees suggests that the Soviet Union has very good guidance systems. Again, however, without knowing what orbits were in-

tended, it is not possible to judge the accuracy of the guidance employed.

In other aspects of science and technology required for a Moon shot, such as circuitry and astronomy, the Soviet Union appears to be sufficiently competent. Miniaturization of electronic components would not be necessary, in view of the large vehicles and powerful rockets used by the Soviet Union.

Conclusions

The Soviet Moon rocket

1. Although absolutely convincing proof is not available, there is a preponderance of good evidence that the Soviet Union, in the first few days of 1959, launched a rocket toward the Moon. (This conclusion is consistent with the fact that free-world reception of radio signals on the announced frequencies was spotty and unsatisfactory. Only specially designed and carefully adapted equipment could be expected to receive the signals. We have sometimes experienced difficulties in receiving signals from our own satellites.)

2. There is enough good evidence to raise a presumption that the Soviet rocket reached the vicinity of the Moon. (The scattered free-world tracking data are consistent with Soviet claims that the vehicle, like our own Pioneer IV, reached "escape velocity.")

3. On the other hand, there is no independent evidence of the exact details of the Soviet Moon shot, such as the time and place of launching, the weight of the vehicle and the closest approach to the Moon.

4. The Soviet rocket was probably intended to hit the Moon, and not merely to come close.

5. There is a reasonable presumption, though no independent evidence, that the Soviet rocket, after passing the Moon, continued in orbit around the Sun. (Since the Earth and the Moon are both themselves in orbit around the Sun, this outcome would not be difficult to achieve—in fact, it would be difficult to avoid.)

Soviet space technology

1. The sending of a rocket to the Moon in early 1959 was within the apparent scientific and engineering capabilities of the Soviet Union. (By starting early, making a consistent large-scale effort, and vigorously exploiting all sources of knowledge both at home and abroad, the Soviet Union seems to have gained a distinct advantage over the United States in space technology. It has made a strong effort in all the many pertinent fields of science and engineering.)

2. In propulsion, the announced Moon rocket would represent no more than a normal progression from the sputniks. (Because of its early attempts to boost heavy warheads by rocket, the Soviet Union has developed a very large reliable booster. The power of Soviet rockets has been independently confirmed from the weights of the sputniks, which can be estimated from their brightness and shape and the length of time they remain in orbit.)

3. There is considerable evidence that Soviet guidance systems are accurate enough for a lunar probe, though it is not possible to be sure, without knowing either the intended orbits of the sputniks or the intended trajectory of the Soviet Moon rocket.

4. There is very little unclassified evidence concerning other aspects of Soviet space technology, such as reentry and tracking capabilities.

As far as it is possible to determine, Soviet scientific and engineering capabilities are adequate in all respects for a lunar probe.

BASIC SCIENTIFIC AND ASTRONAUTIC RESEARCH IN THE DEPARTMENT OF DEFENSE

House Resolution 500 of the 85th Congress, which created the Committee on Science and Astronautics, specifically charged the committee with the responsibility for scientific research and development conducted by the Federal Government. As a result, the committee held hearings on the research and development program of the Department of Defense.

Hearings were held on June 4, 8, 9, 10, 11, 12, 18, 19, and 30, and July 7, 1959. Witnesses heard were—

Department of Defense

McNeil, Wilfred J., Assistant Secretary of Defense (Comptroller).
York, Dr. Herbert F., Director, Defense Research and Engineering.

Department of the Army

Bayer, Lt. Col. Kenneth H.
Britton, Brig. Gen. Frank, Director, Developments.
Davison, Col. Michael S.
Dick, Maj. Gen. William W., Director, Special Weapons.
Ely, Brig. Gen. William T., Director, Research.
Frolich, Dr. Per R., Chief Scientist, Chemical Corps.
Power, Dr. Roy B., Chief Scientist, Ordnance Corps.
Rankin, Lt. Col. Alexander.
Scandrett, Col. William.
Siu, Dr. Ralph G. H., Chief Scientist, Quartermaster Corps.
Walters, Lt. Col. James W.
Willmann, Lt. Col. W. G., Office of the Chief Chemical Officer.
Woodside, C. R., financial adviser, Office, Chief of Research and Development.

U.S. Navy

Bennett, Rear Adm. Rawson, Chief, Office of Naval Research.
Coates, Rear Adm. L. D., Assistant Chief, Bureau of Aeronautics (Research and Development).
Hayward, Vice Adm. John T., Deputy Chief of Naval Operations, Research and Development.
Kershner, Dr. R., technical director, transit program, Applied Physics Laboratory, Johns Hopkins University.
Kinney, Capt. Sheldon H.
Maris, Maj. Gen. Ward H., USA (retired), consultant to the Defense Department in the Office, Chief of Research and Engineering.
Masterson, Rear Adm. K. S., Assistant Chief of Naval Operations, Development.
Metsger, Capt. Alfred, Deputy and Assistant Chief, Office of Naval Research.

U.S. Air Force

Charyk, Dr. Joseph V., Assistant Secretary of the Air Force (Research and Development).
Schriever, Lt. Gen. Bernard A., Commander, Air Research and Development Command.
Wilson, Lt. Gen. R. C., Deputy Chief of Staff (Development).

Advanced Research Projects Agency

Godel, William H., Director of Policy and Planning.
Sutton, George P., Chief Scientist.

The full committee received testimony on the overall research and development program of the Defense Department, while four subcommittees were made responsible for studying the various programs conducted by the Army, Navy, Air Force, and the Advanced Research Projects Agency.

Subcommittee assignments were as follows:

Subcommittee No. 1: ARPA.
Subcommittee No. 2: Army.
Subcommittee No. 3: Navy.
Subcommittee No. 4: Air Force.

Department of Defense

The establishment on February 10, 1959, of the Office of Director of Defense Research and Engineering centralized the supervision and executive management of all research and development programs in the Department of Defense. As the President stated to Congress last year, in submitting the plan for reorganization of the Department of Defense, the Director is to be the principal adviser to the Secretary of Defense on scientific and technical matters, to supervise all research and engineering (development) activities in the Department of Defense, including those of ARPA, and the Office of Guided Missiles, and to direct research and engineering activities that require centralized management. This involves the expenditure in fiscal year 1960 of almost $6 billion, an unprecedented task of monumental proportions involving about 2,000 distinct projects incorporating many thousand separate subprograms.

Such statistics serve, if nothing else, to highlight the complex problem of selection—that is, making the necessary decisions with regard to what projects are to be funded and pursued.

The general management of thousands of projects requires a continuous flow of information between the Director of Defense Research and Engineering and the responsible DOD agencies, to provide the means by which day-to-day decisions can be made.

Coordination with research and engineering activities conducted by other Government agencies is continuously maintained. For instance, close liaison is maintained with the Atomic Energy Commission with regard to work in nuclear development which contains promise of practical military application.

Coordination is also maintained with the Department of the Interior; Department of Health, Education, and Welfare; Federal Avia-

tion Agency; National Bureau of Standards; National Science Foundation; and Federal Maritime Board, on current research being conducted by these organizations which is of interest and use to the Department of Defense.

It is apparent that the R.D.T. & E. program must perform two vital functions for our Armed Forces. First it must provide the DOD planners with the necessary technical information for deciding upon the most practical course of action for future weapon systems, and, secondly provide the means by which these decisions can be brought to reality.

U.S. Army

The Army, perhaps even more than its sister services, must depend on a comprehensive research and development program to remain effective in combat situations, whether these are global or local. This is because traditional concepts of land warfare have changed very rapidly since World War II and are continuing to change. While it may be expected that the most probable active use of the Army in the foreseeable future would be in regard to the so-called brushfire war, the Army must nonetheless depend on extensive new techniques and systems inasmuch as it is almost certain to be far outweighed in terms of the opposition's manpower.

Budgetwise, the Army research and development program is, at present, just barely "getting by." Witnesses feel that the Army is not prosecuting more than half of the possible research areas which might be of genuine utility to the Army. In view of the swift scientific pace going forward today, research and development money clearly seems inadequate.

The amount of research and development money actually being expended by the Army on basic and applied research, as distinguished from its developmental, test, and evaluation activities, appears to be very low.

In its efforts to reduce the leadtime necessary for the development of new weapons and weapons systems, the Army (as well as other services) is definitely handicapped by a multiplicity of decision levels and by bureaucratic contract procedures which, while designed to assure economy and democratic fairness, are often excessively time consuming.

The Army is presently handicapped by inadequate authority to investigate and research certain areas of possible warfare which might be termed "exotic" or "unorthodox." These areas would include but not be limited to such concepts as chemical warfare, biological warfare, psychological warfare, decibel warfare, and microwave warfare.

U.S. Navy

In addition to a general dependence on research and development, which it shares with the Army and the Air Force, the Navy has unique R. & D. requirements resulting from carrier operation of aircraft, shipboard use of missiles, Marine Corps needs, and submarine and antisubmarine operations.

Research and development funds constitute only 8.5 percent of the total Navy budget for fiscal 1960. An increase of more than $150 million would be needed to raise this percentage to 10 or so, as recom-

mended by Admiral Hayward. (Comparable percentages in the Army and the Air Force are 10 or more.)

There has been essentially level funding over the past few years of basic and supporting Navy research and development, in spite of inflation and the increasing rate of technological change. The Navy budget for basic and supporting research—as distinguished from applied development, test, and evaluation—is thus becoming relatively lower, year by year. Witnesses testified that the Navy program of basic and supporting research has not received its proportionate share of increases over the past few years in Defense Department funds.

Fleet air defense has kept pace with weapons of attack against surface ships by shifting to greater reliance on missiles. This is in marked contrast to continental air defense, for which increasingly big and fast fighter aircraft have been built, to cope with the improving performance of attack missiles and aircraft. The use of bigger and faster fighter aircraft for fleet air defense is limited by handling and operating requirements aboard carriers and by fuel requirements.

Research and development in the field of electronics (for both detection and communications) appears to be making good progress, but at too low a level of support. Data-processing systems are receiving major emphasis.

According to Navy witnesses, the major gaps in the Navy research and development program are basic and supporting research, component development and electronics.

Navy funds for research, development, test and evaluation should be raised to 10 percent or more of the total Navy budget, and that half or more of such funds be provided for basic and supporting research. Regardless of budgetary levels, greater emphasis should be placed on basic and supporting research, component development, electronics and attack aircraft (especially aircraft-missile attack systems).

The Navy's foreign contract research program should be moderately increased in budget, and extended to additional countries (including non-European countries).

The problem of continental defense against submarine-launched missiles should receive further study, with special attention to the possible prohibition of submerged foreign submarines off U.S. coasts with a distance of at least 200 miles.

U.S. Air Force

The Soviet leaders, by taking advantage of their unlimited authority, have been able to reduce dramatically the leadtime between concept and reality—a factor that has had a significant effect upon international military postures. It is this concept of leadtime that can determine whether or not this country will maintain its military power generally superior to that of Russia.

The Air Force has developed two basic, governing philosophies of research and development that have been successful in helping to reduce drastically the timelag between conception and realization that has hamstrung, in the past, our efforts to match the rate of Soviet technological progress.

The first relates to specific weapons systems and to the status of the component elements. By weighing knowledge against possibility of

achievement, a decision to proceed with the development of a given system can be based on a margin of tolerance well within the limits of calculated risk, even though at the time of decision, none of the essential component parts of the system actually exist.

The second philosophy actually concerns the methods by which the first can be applied in the most advantageous manner. It is what the Air Force terms "concurrency of development." It involves all those factors that are directly related to a given weapons system that must be developed concurrently along with the development of the whole system, and must be ready for incorporation into its proper place at the proper time.

As the manager rather than the performer of its research programs, it is essential that the Air Force have the capability to provide the proper guidance and direction to the contractors and to be able to evaluate precisely the research products. This applies not only to whole systems but also to the "nuts and bolts" of the subsystems as well. The imperative need for talent on all levels is underscored by the vital strategic responsibility borne by the Air Force.

The Air Force does not have sufficient scientific and technical personnel, and is faced yearly with the loss of valuable personnel to commercial firms through inducements of salaries much higher than the Air Force can pay.

It is generally acknowledged that in the broad area of basic research and development, European scientists are traditionally better oriented to this type of investigation than are our own. Further, it is obviously within the field of interest of the Air Force to draw upon foreign programs of research wherever possible that would contribute substantially to our own efforts. This activity is being pursued vigorously by ARDC through its European office and through Air Force liaison with the mutual weapons development program in connection with the NATO countries.

Advanced Research Projects Agency

ARPA has the responsibility of centralized management at the highest level and it was created to avoid unnecessary duplication and to establish the high priority called for in the highly specialized and extremely costly job of space research and development. This responsibility can be exercised effectively and economically only by selecting, with utmost care, the extremely high-cost programs and projects so as to make maximum use, not only of the time element involved but also of the supply of technical talent, material resources, and funds required to achieve the ultimate goal.

At the present time ARPA has under contract approximately 40 scientific personnel. ARPA has been assigned expanded functions in the field of missile defense, and it is felt that presently there are insufficient scientific personnel under contract to properly do the job assigned the agency. This "tight personnel" problem is, it is felt, only temporary in that the tasks assigned by the Secretary of Defense had been expanded immediately preceding the hearings held on June 9.

ARPA is an organizational entity in the defense setup which specializes in resolving a particular problem and in reducing the unknowns in the research and development area to proportions that would enable the Secretary of Defense to assign the problem to one of

the defense agencies which, in turn, will be charged with the problem of placing into operation ARPA's development.

ARPA is charged with the management of research and development in the following three areas: (1) military space technology, (2) ballistic missile research, and (3) solid propellant technology.

In order to solve the problems arising under the three broad project areas, ARPA uses five different types of research and development effort. These are as follows: (*a*) fundamental research, (*b*) applied research, (*c*) development of critical components, (*d*) system feasibility demonstration experiments, and (*e*) systems studies.

PROGRESS OF POLARIS AND ATLAS MISSILES

A series of mishaps in the Atlas and Polaris missile flight test programs aroused the committee's concern for the progress being achieved in the research and development programs associated with these rockets. As a result, hearings were held July 28 and 29, 1959, to receive testimony from Lt. Gen. Bernard A. Schriever, USAF, commander of the Air Research and Development Command, and from Rear Adm. W. F. Raborn, USN, Director of Special Projects.

As it has evolved, the Atlas has become a vehicle of great importance, not only to our national defense but also to our satellite and man-in-space projects. It is a liquid-fueled missile employing liquid oxygen and kerosene (JRP) and has three engines (two boosters and one sustainer) delivering 360,000 pounds of thrust to lift about 250,000 pounds at takeoff. It employs an inertial guidance system and has one-and-a-half stages—that is, separation involves only the booster engines and not tankage—stands about 80 feet high and measures about 10 feet in diameter.

At the time of the hearing 26 Atlases, less than half the number scheduled in the test program, had been fired. Of that total, 11 had been completely successful in that they had achieved within established tolerances all planned objectives. However, included in the 15 so-called failures were the 5 successive abortive flights that brought committee action. Three of the five were caused by unrelated malfunctions which have been determined and remedied. The remaining two, the first and last of the series, were related in that the same difficulty caused the malfunction of the rockets and aborted the flights. It is believed that these too have been determined and remedied, and that scheduled tests in the future will prove the validity of the "fixes."

The Polaris, although it does not compare statistically with the Atlas, insofar as range is concerned, does offer an intercontinental ballistic missile effectiveness because of the association of the missile system with surface and underwater vessels.

The Navy, as a result of its early studies into the potential utilization of large, high performance rockets in a naval role, decided upon the use of solid propellant because of the many factors involved in shipboard operations. Significant breakthroughs by Navy R. & D. in improving the thrust obtainable with solid propellants, the development of small high-yield nuclear warheads by the Atomic Energy Commission and the unqualified success of the nuclear-powered submarine *Nautilus* gave the Navy the major elements it needed for a practical and effective weapon system.

At the time of Admiral Raborn's testimony, 33 Polaris test vehicles had been fired. Of these, 24 were considered successful in meeting test objectives, 7 were partially successful, and 2 were failures, although contributing valuable information.

Although the committee hearings were quickly scheduled and necessarily short, intense and cogent interrogation by the members brought to light important facts pertaining to the progress of research and development in the Atlas and Polaris programs. In sum, the hearings showed that—

(*a*) Despite the widespread publicity of abortive missile flights that occurred during the recent weeks, the fact is that both projects are progressing at a highly satisfactory rate and that there is no doubt in either the Air Force or the Navy that their respective missiles will be operational on or about their scheduled dates.

(*b*) There is a great disparity between the popular and the scientific concept of what constitutes a "missile failure." With few exceptions, almost every missile test flight, whether it flies perfectly or is destructed only seconds away from the launch pad, provides some valuable information that is indispensible to the progress of the testing program and the improvement of the missiles. It therefore becomes clear that in reality both the Air Force and the Navy have had very few abortive flights that could be classified as complete "failures," and that *none* of the less-than-completely successful launches has compromised either testing program.

However, it would be unrealistic to infer that the abortive attempts were equal in achievement to the completely successful flights and that the people responsible for the tests were satisfied with those partial and often meager results.

(*c*) Both the Air Force and the Navy have achieved an outstanding record in the planning, organization, and management of their respective research and development missile programs. Despite all the possible vicissitudes inherent in testing such rockets, the Air Force has suffered only a 60-day slippage in a 4-year testing schedule, and the Navy, after compressing the original Polaris timetable by 5 years, is highly confident of placing in operational status a working missile system on the scheduled date.

It is the belief of the committee that the Congress and the American people can be assured the development of our ICBM strength has suffered no real setback by recent events, and can confidently expect that each new objective achieved by our rocket programs will be an additional guarantee for peace and our future security.

Contracts and Contract Procedures

An important field in which the committee is pursuing an active interest is that involving contracts and contract procedures of the executive agencies over which the committee has jurisdiction. These agencies include the National Aeronautics and Space Administration, the National Bureau of Standards, and the National Science Foundation.

One of the major responsibilities of the committee is to maintain a legislative oversight over the contracts entered into by these agencies and the contract procedures they employ.

On June 23, 1959, Chairman Overton Brooks announced to the committee that he had named two members of the staff to handle this assignment. The chairman stated:

> I want to take this opportunity to inform members of the committee that I am appointing two members of our staff, Mr. Raymond Wilcove, staff consultant, and Mr. John Carstarphen, counsel, to make a continuing study of the contracts and contract procedures of the National Aeronautics and Space Administration and the other agencies over which this committee has jurisdiction.
>
> Mr. Wilcove and Mr. Carstarphen will work closely with the General Accounting Office and will report their findings and recommendations to me so that I can determine whether further committee action is justified. In cooperation with the Comptroller General, one study is now in progress relating to a $102 million NASA contract with the Rocketdyne Division of North American Aviation, Inc., for the development of a large single-chamber engine. This study is expected to take approximately 2 months to complete.
>
> When the study is completed, we will review it and decide whether it is a full committee matter or whether it should go to a subcommittee.

In accordance with the chairman's directive, staff conferences were held with the various concerns which submitted bid proposals for the engine contract. These were:

Rocketdyne Division, North American Aviation, Inc.; Aerojet-General Corp.; Aircraft Gas Turbine Division, General Electric Co.; Pratt and Whitney Aircraft Division, United Aircraft Corp.; Reaction Motors Division, Thiokol Chemical Corp.; Wright Aeronautical Division, Curtiss-Wright Corp.; Bell Aircraft Corp.

Staff conferences were also held on the NASA-Rocketdyne contract with representatives of the General Accounting Office and with the National Aeronautics and Space Administration.

The staff also launched a study, in collaboration with the GAO, of a $19,450,000 NASA contract with the McDonnell Aircraft Corp., of St. Louis, Mo., for the design and fabrication of a manned satellite capsule. This is the capsule in which an American astronaut will attempt to orbit the earth.

Other studies of contracts and contract procedures are also underway and more are anticipated in the months ahead.

For the future, the committee plans to keep a watchful eye on the contract activities of the Government agencies over which it exercises jurisdiction.

Patents and Scientific Inventions

In July the chairman appointed a special Subcommittee on Patents and Scientific Inventions, composed of Erwin Mitchell, Georgia (chairman); James M. Quigley, Pennsylvania; Emilio Q. Daddario, Connecticut; David S. King, Utah; James G. Fulton, Pennsylvania; J. Edgar Chenoweth, Colorado; and Perkins Bass, New Hampshire.

The subcommittee is a continuing one with the function of reviewing legislative problems of ownership in scientific inventions. Since half of all research and development in the United States is now done under contract with the Federal Government, this problem of patent rights has become of special significance. Also since most inventions and discoveries come out of organized scientific research and development, the Committee on Science and Astronautics has a particular interest in this area of patent law.

The first task of the subcommittee has been to review the patent sections of the National Aeronautics and Space Act of 1958, together with the interpretations placed on them by NASA. To this end the committee on August 19 and 20, 1959, heard:

John A. Johnson, General Counsel, NASA.

G. D. O'Brien, patent specialist, NASA.

Ray M. Harris, formerly Chief Patent Adviser, DOD, presently patent specialist, NASA.

The subcommittee has thus far undertaken only to inform itself on existing patent situations, mainly within the Government. It contemplates full hearings at a future date in the field of patents-scientific research.

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